

INSTALLATION RESTORATION PROGRAM

FINAL

SITE ASSESSMENT REPORT VOLUME I

111th FIGHTER GROUP
WILLOW GROVE AIR RESERVE STATION
PENNSYLVANIA AIR NATIONAL GUARD
WILLOW GROVE, PENNSYLVANIA

MARCH 1996



HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
Environmental Restoration and Waste Management Programs
Oak Ridge, Tennessee 37831-7606
managed by LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the U.S. DEPARTMENT OF ENERGY under contract DE-AC05-84OR21400

RAPID RESPONSE INITIATIVE

**FINAL
SITE ASSESSMENT REPORT
MOTOR POOL AREA, BUILDING NO. 352**

**111th FIGHTER GROUP
WILLOW GROVE AIR RESERVE STATION
PENNSYLVANIA AIR NATIONAL GUARD
WILLOW GROVE, PENNSYLVANIA**

MARCH 1996

Prepared for

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Submitted by

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Oak Ridge, Tennessee 37831-7606
Managed by
Lockheed Martin Energy Systems, Inc.
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LIST OF ACRONYMS

AFRS	Air Force Reserve Station
ANG	Air National Guard
ANGRC	Air National Guard Readiness Center
ANGS	Air National Guard Station
API	American Petroleum Institute
AST	aboveground storage tanks
ASTM	American Society for Testing and Materials
BGS	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
BUCK	Buck Environmental Laboratory
BWQM	Bureau of Water Quality Management
°C	degrees Celsius
CFR	Code of Federal Regulations
cm/sec	centimeters per second
COC	chain-of-custody
DOE	Department of Energy
DOT	Department of Transportation
D&M	Dames & Moore
Energy Systems	Martin Marietta Energy Systems, Inc.
EPA	Environmental Protection Agency
°F	degrees Fahrenheit
ft	feet
ft ²	square feet
GC	gas chromatograph
gal	gallon
gpm	gallons per minute
HAZWRAP	Hazardous Waste Remedial Actions Program
HSA	hollow stem auger
IAG	Interagency Agreement
I.D.	inside diameter
in.	inch
La	Lansdale Loam
Le	Lawrenceville Silt Loam
MeB	Made Land
MCL	maximum contaminant level
mL	milliliter
MOGAS	automobile gasoline
MPA	Motor Pool Area
MSL	mean sea level
MW	monitoring well
NA	not applicable
NAS	Naval Air Station
ND	not detected
NI	not installed at time of static water level measurement
NM	not measured
NR	not requested to be analyzed

LIST OF ACRONYMS (Continued)

NW	no water encountered
SB	soil boring
$\mu\text{g/g}$	micrograms per gram
$\mu\text{g/l}$	micrograms per liter
USDA/SCS	U.S. Department of Agriculture/Soil Conservation Service
OVA	organic vapor analyzer
oz	ounce
PAANG	Pennsylvania Air National Guard
PADER	Pennsylvania Department of Environmental Resources
PEER	PEER Consultants, P.C.
PID	photoionization detector
POL	petroleum, oil, and lubricant
ppb	parts per billion
ppm	parts per million
ppmv	parts per million per volume
PVC	polyvinyl chloride
QAP	Quality Assurance Procedure
QA/QC	quality assurance/quality control
RECRA	RECRA Environmental Laboratory
RI	Remedial Investigation
RRI	Rapid Response Initiative
SA	site assessment
SOP	Standard Operating Procedure
SOW	Statement of Work
SVOC	semivolatile organic compounds
TAG	Tactical Air Group
TCL	Target Compound List
TOC	top of casing
TPH	total petroleum hydrocarbons
UST	underground storage tank system
VOC	volatile organic compounds
WGARS	Willow Grove Air Reserve Station
WP	Work Plan
WPA	Work Plan Addendum
yd^3	cubic yards

**MOTOR POOL AREA, BUILDING NO. 352
SITE ASSESSMENT REPORT**

1.0 INTRODUCTION

1.1 BACKGROUND

This report outlines the findings of the Site Assessment (SA) which was conducted at the Motor Pool Area (MPA), Building No. 352, located at the 111th Fighter Group, Pennsylvania Air National Guard (PAANG), Willow Grove Air Reserve Station (WGARS). The WGARS (Figures 1.1 and 1.2) is located in the city of Willow Grove, Pennsylvania. The SA activities were performed in response to the detection of soil and groundwater contamination during the closure of two underground storage tank systems (USTs) at the MPA.

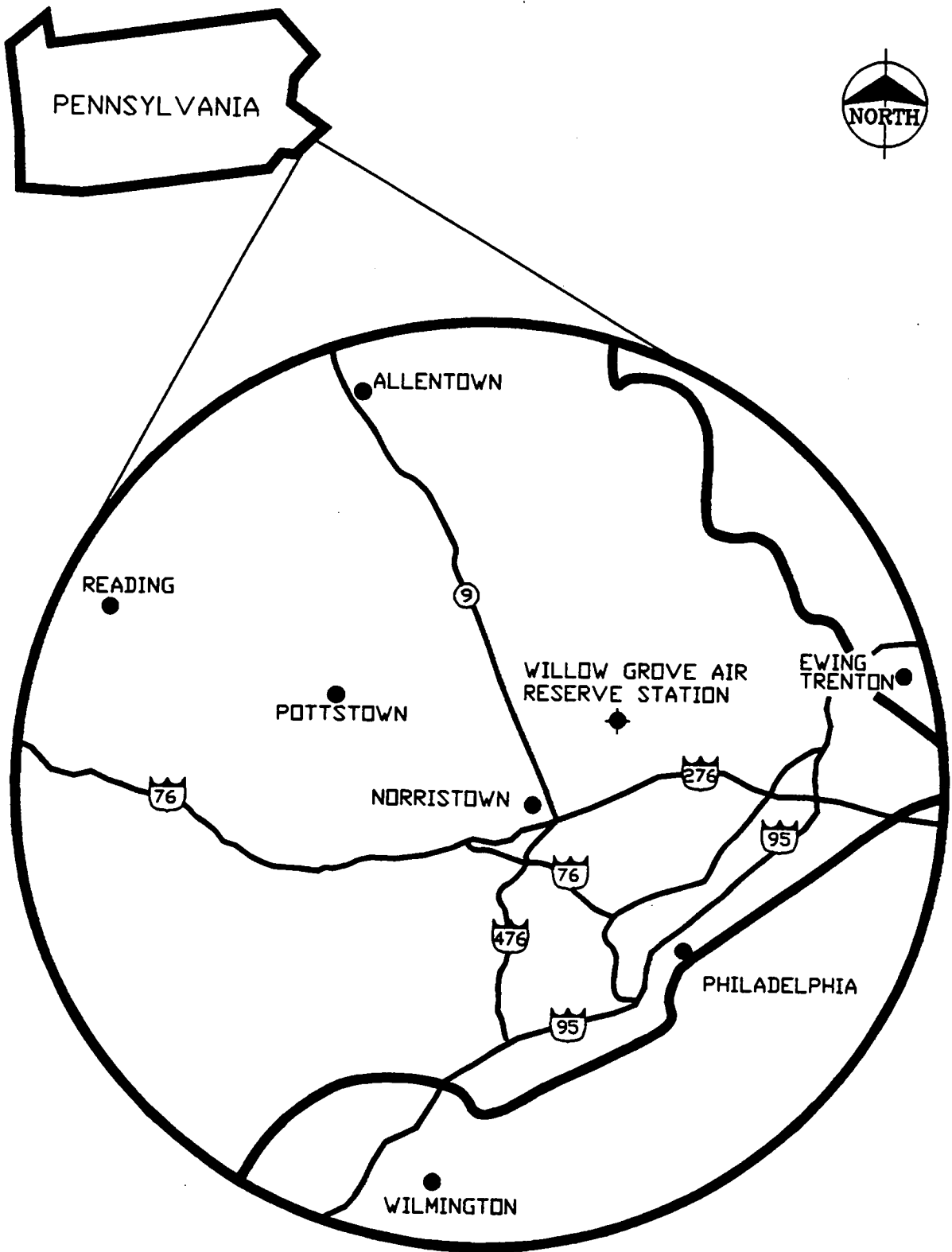
The Air National Guard Readiness Center (ANGRC) has developed the Rapid Response Initiative (RRI) to conduct site assessments, evaluate potential corrective actions, and design the selected remedies at leaking UST and spill sites at Air National Guard (ANG) facilities. The Department of Energy (DOE), through an existing Interagency Agreement (IAG) with the Air Force, provides technical assistance in implementing the RRI for the ANGRC. Lockheed Martin Energy Systems, Inc. (Energy Systems), was assigned the responsibility of managing the Hazardous Waste Remedial Actions Program (HAZWRAP) for DOE. This report was prepared by PEER Consultants, P.C. (PEER), under the direction of HAZWRAP.

1.2 PREVIOUS INVESTIGATIONS

1.2.1 Willow Grove Air Reserve Station

A Remedial Investigation (RI) Report was prepared for WGARS by Dames & Moore (D&M) in 1988.¹ Three areas of potential environmental concern were evaluated during the RI. These areas, which are shown on Figure 1.3, include the Petroleum, Oil, and Lubricant (POL) Area (Buildings 207, 208, 224, and 228); the Open Drum Storage Area (Buildings 433 and 434); and the Ponding Basin.

The POL area is contained within a fenced area approximately 400 feet by 200 feet. A total of four above ground storage tank systems (ASTs) exist in this area. Two ASTs are used for storing JP-4 fuel and have capacities of 210,000 gallons (gal) and 105,000 gal. Two smaller ASTs in this area (15,000 and 2,000 gal) are used for storing jet fuel and contaminated fuel, respectively. The two large tanks were installed in the 1950's when the base was commissioned. The original containment berms surrounding the ASTs were earthen and were replaced with concrete lined berms in 1979. Prior to 1979, several undocumented spills of between 5000 and 30,000 gal of



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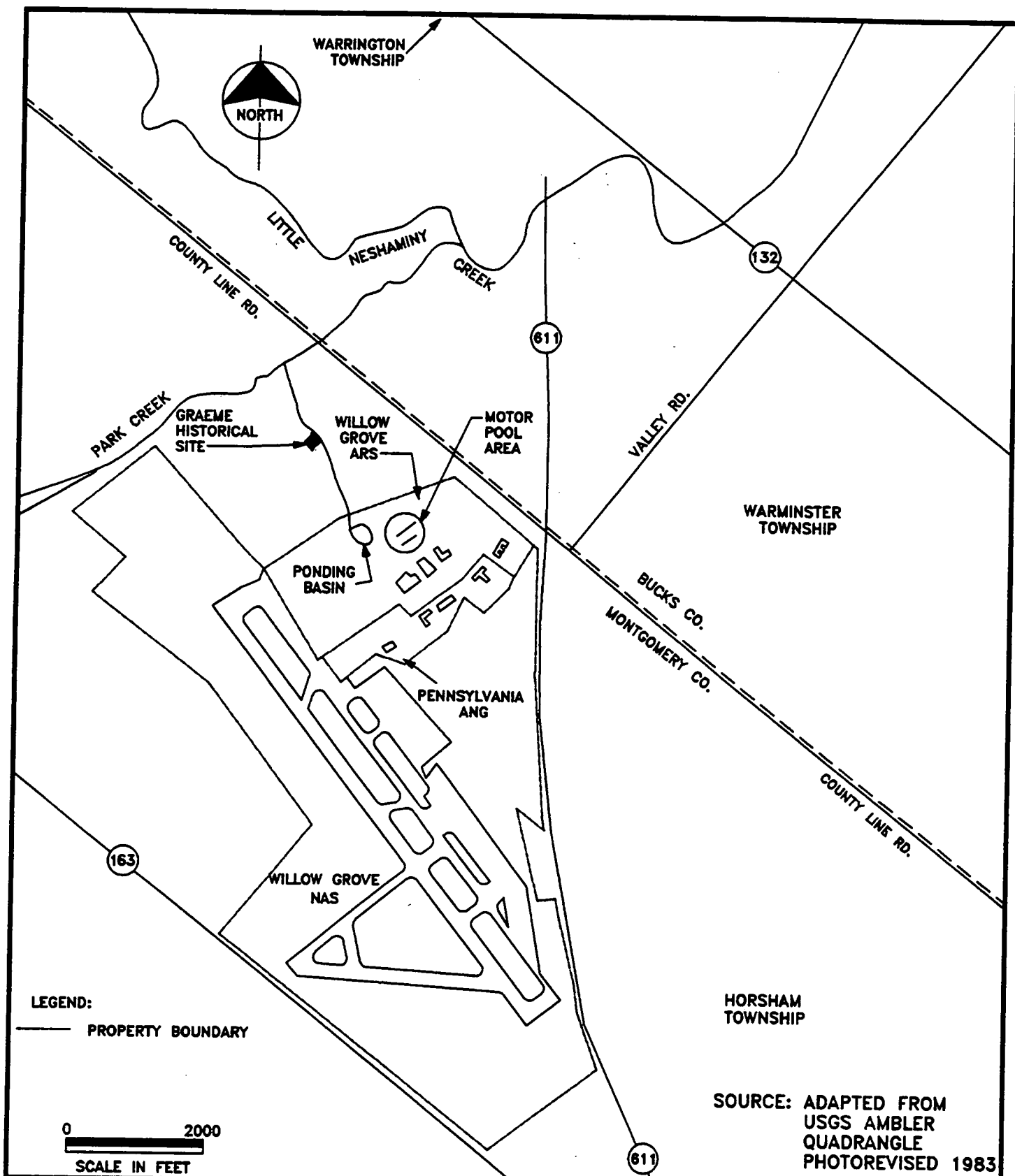
FIGURE 1.1 AREA OVERVIEW
WILLOW GROVE AIR
RESERVE STATION

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SCALE: AS INDICATED

FILE: WG-FIG11.DWG



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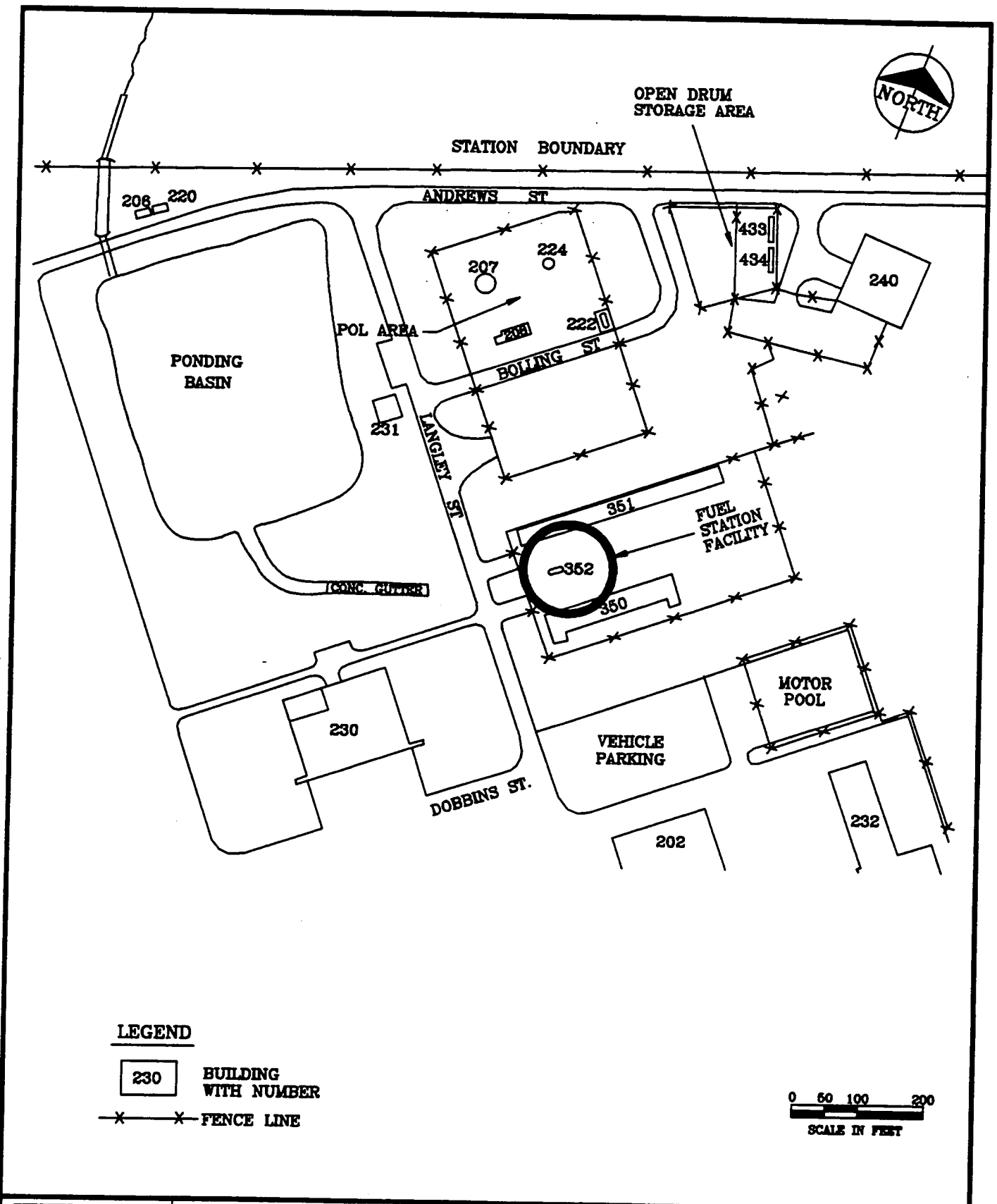
FIGURE 1.2 LOCATION MAP
WILLOW GROVE AIR
RESERVE STATION

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FILE: WG-FIG12.DWG



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FIGURE 1.3 FUEL STATION FACILITY
LOCATION MAP

WILLOW GROVE AIR RESERVE STATION

PROJ./DISK: 1443-K11

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SCALE: AS INDICATED

FILE: WG-FIG13

JP-4 are reported to have occurred.¹ In early 1979 a leak in the base of the 210,000 gallon AST was discovered. An estimated 8000 gal of JP-4 was released.¹ Smaller quantities of aviation oil, motor gasoline and No. 6 fuel oil may also have been released during undocumented spills or leaks associated with past operations.¹

The RI by D&M¹ confirmed the existence of petroleum contamination of groundwater within the shallow unconfined aquifer due to a release of JP-4 jet fuel at the POL Area. Figure 1.4 shows the area encompassed by the impacted groundwater as defined by D&M and the locations of the D&M monitoring wells. Free-phase product was identified on the water table in an approximate 5-acre area that extended from beneath the POL Area to the Ponding Basin, to beneath the Open Drum Storage Area to approximately 100 ft north of the facility boundary. An additional 13 acres of groundwater contaminated by dissolved JP-4 chemical constituents were identified during the D&M RI.¹ These 13 acres were located both on-site and extended off-site toward the north and northwest.

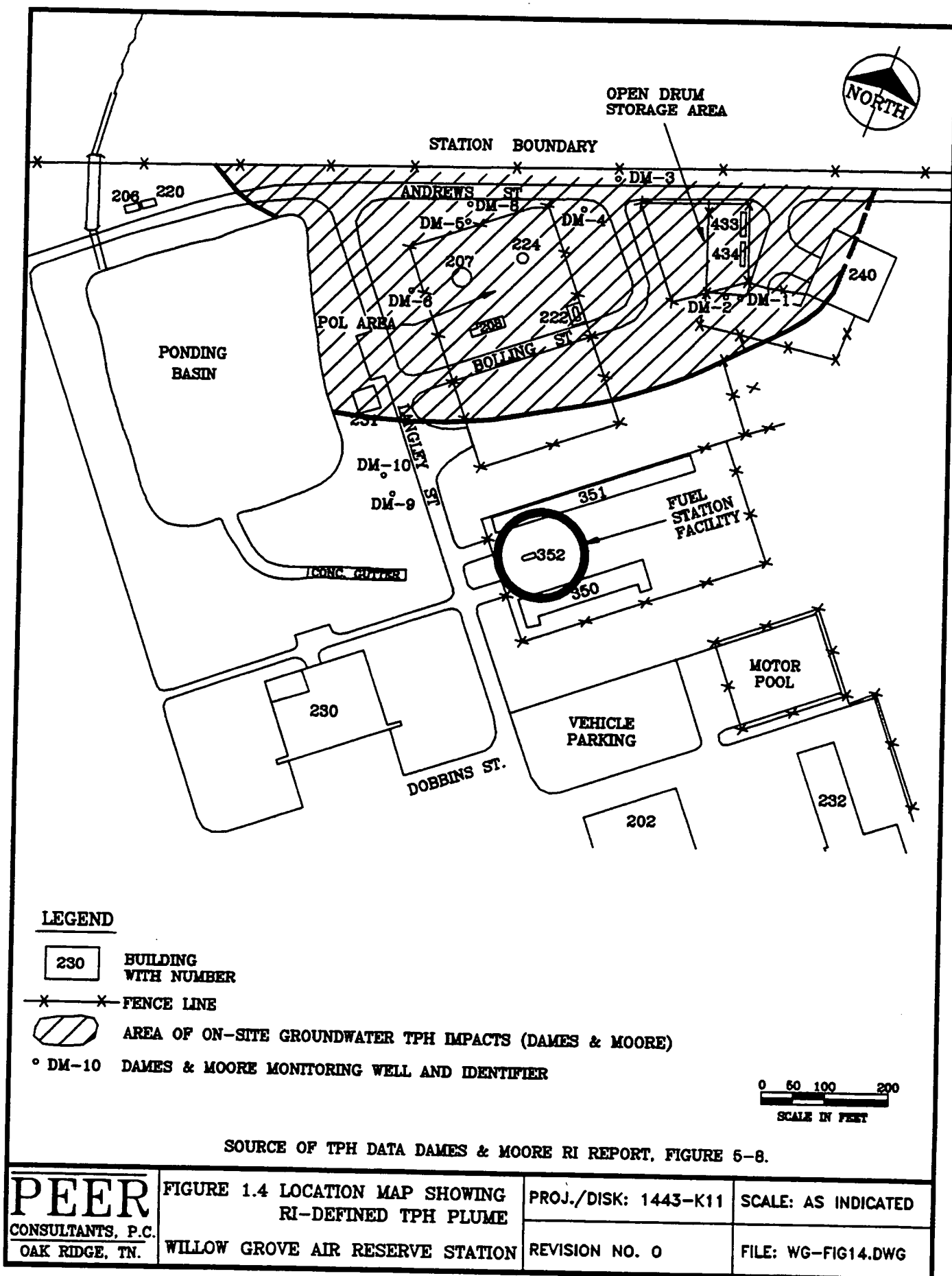
1.2.2 Motor Pool Area, Building 352

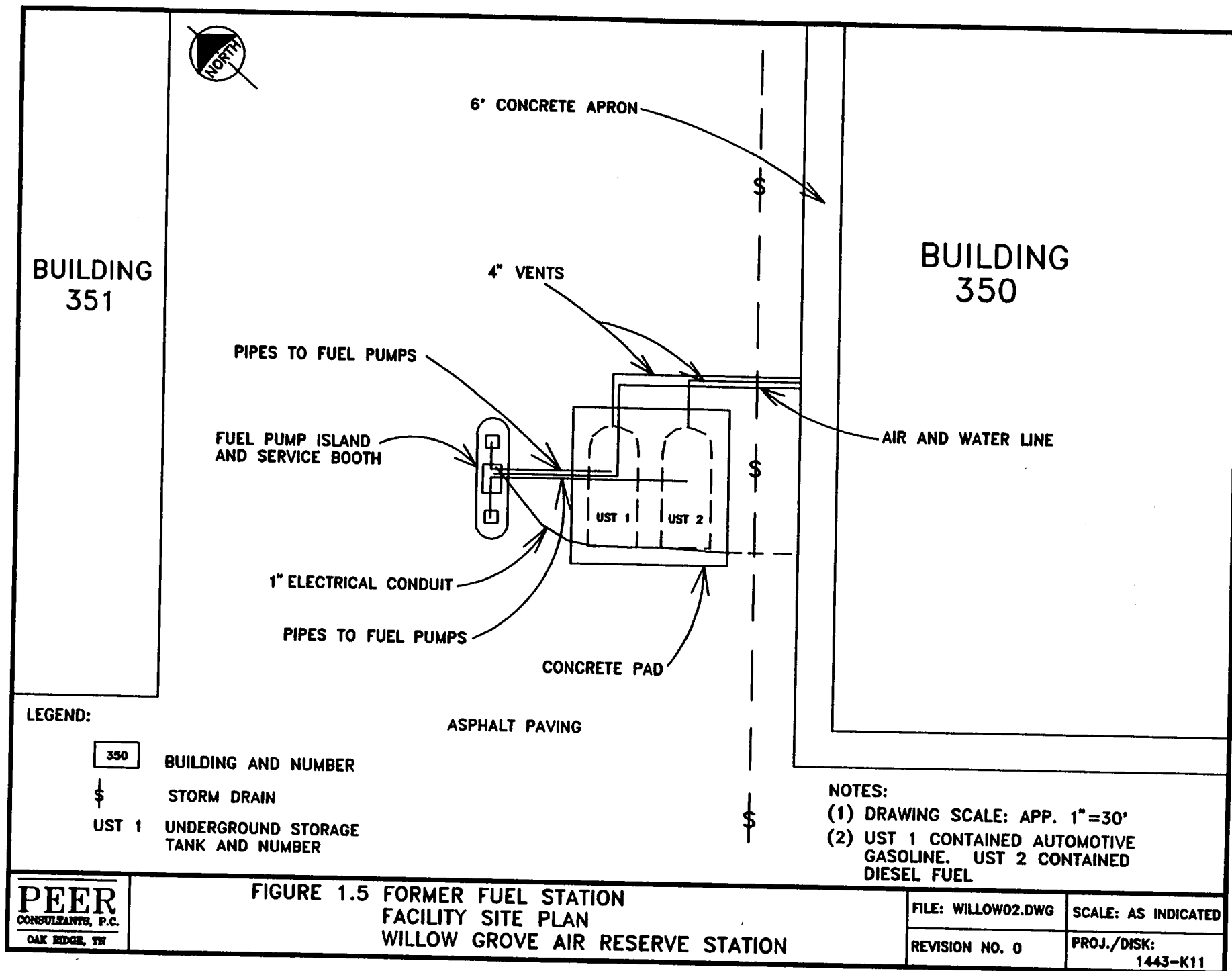
The Fuel Station Facility (Building 352) was located within the motor pool area in the northern portion of the WGARS (Figure 1.3) within the Auto Maintenance Area. Building 352 was located between the Auto Storage Shed (Building 351) and the Auto Maintenance Shop (Building 350). The Fuel Station Facility consisted of two 6000-gal nominal capacity USTs and a refueling island (Figure 1.5). The two USTs were made of fiberglass and were covered with a concrete pad. They were installed at the Fuel Station Facility in 1974; one was used for storage of automotive gasoline (MOGAS) and the other contained diesel fuel.

In 1990, the diesel fuel tank was filled to capacity in preparation for tank tightness testing. However, approximately 1000 gal leaked from the tank prior to performing the test. The leak was reported to the Pennsylvania Department of Environmental Resources (PADER) on May 16, 1990. The tank was emptied and taken out-of-service. WGARS personnel also reported that it had been standard procedure prior to this leak event to fill the tank to 80% capacity. This practice indicates that the tank may have leaked in the past.

1.2.3 UST Closure

During May 1992, a tank system closure was performed on the two USTs at the Fuel Station Facility (Building 352). The USTs were removed in accordance with American Petroleum Institute (API) document 1640. During the closure, all pumpable products and liquids were removed from each tank. The atmosphere within each tank was inspected prior to entering each tank for final cleaning and wipe down. Upon the completion of the wipe down, both tanks and appurtenances were crushed and taken to a designated landfill, along with the excavated soil. During this closure, 290 yd³ of





soil were reportedly excavated from the tank cavity and transported to a designated landfill.

Analysis of post excavation soil and groundwater samples indicated that soil and groundwater contamination above the PADER action levels existed in the tank cavity at the site. A copy of the tank closure report is contained in Appendix A.

1.3 SITE DESCRIPTION

The WGARS is located in Montgomery County, Pennsylvania, immediately adjacent to and north of the Willow Grove Naval Air Station. It is situated approximately 23 miles north of Philadelphia, in Horsham Township. The entire Naval Air Station encompasses approximately 162 acres and is surrounded by residential areas and agricultural land to the north and west. Residential, industrial, and commercial areas lie to the south and east. The 111th Tactical Air Support Group of the PAANG leases a portion of the facility from the 913th Tactical Airlift Group (TAG). The primary mission of the 913th TAG is to achieve and provide, through training, the capabilities for various air transport and air evacuation activities; to operate and maintain air terminals and base facilities; and to provide support to assigned units.

The MPA location (Building Nos. 350 and 351, and former Building 352) is shown on Figures 1.2 and 1.3, and is located in the extreme northern portion of the Willow Grove Naval Air Station. Building 352 which housed the Fuel Station Facility was demolished during tank closure activities in May 1992. This area between Buildings 350 and 351 is currently paved with asphalt.

1.4 ENVIRONMENTAL SETTING

1.4.1 Meteorology

The WGARS is located in the eastern piedmont area of the Appalachian Mountains. The Atlantic Ocean is to the east of the WGARS. The Appalachian Mountains and the Atlantic Ocean have a moderating influence on the local climate. January is the coldest month, with an average temperature of 32.6° F, and July is the warmest month, with an average temperature of 76.7° F. This region averages 41.26 in. of annual precipitation.² The average annual snowfall is 20.3 inches (U.S. Department of Commerce 1974). Average annual evapotranspiration in adjacent Bucks County is estimated to be 27 inches per year.³ The 1-year, 24-hour rainfall event is used to measure rainfall intensity. Based on data obtained from Philadelphia International Airport, the rainfall intensity in the vicinity of WGARS is estimated to be about 2.7 in. for a 24-hour period.

1.4.2 Topography

The WGARS is located in the Triassic Lowlands physiographic province. Elevations range from 264 ft above mean sea level (MSL) to 315 ft above MSL. The maximum elevation at the WGARS occurs along Privet Road near Building 217. The topography is mostly level and slopes gently toward the Ponding Basin located in the northern portion of the station. Off-base to the north-northwest lies a broad drainage valley (Keith Valley) which slopes gently to the northeast. Elevations in the Keith Valley range from approximately 280 ft at the head wall of the valley to approximately 220 ft in the area where Park Creek joins Little Neshaminy Creek (Figure 1.6).

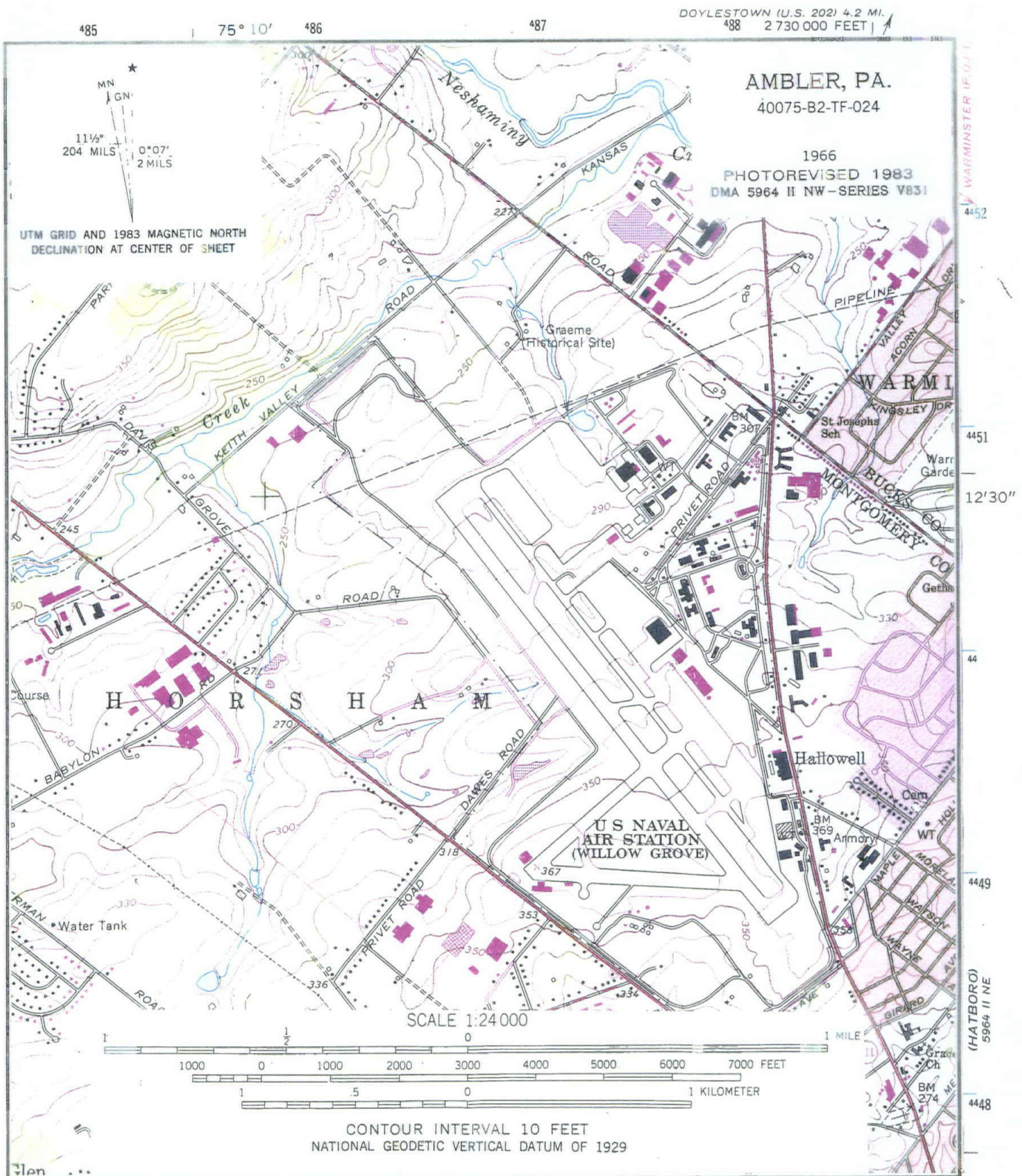
1.4.3 Geology

The WGARS is located in the eastern piedmont area of the Appalachian Mountains. This region is referred to as the Triassic Lowland Physiographic Province. The geology of the strata underlying the Air Reserve Station consists of unconsolidated deposits overlying sedimentary bedrock. The unconsolidated deposits have been classified as Made Land. Made Land soils are located in areas that have been disturbed, filled, or regraded so that the physical properties of the soil are characteristically different from undisturbed in-situ soils.

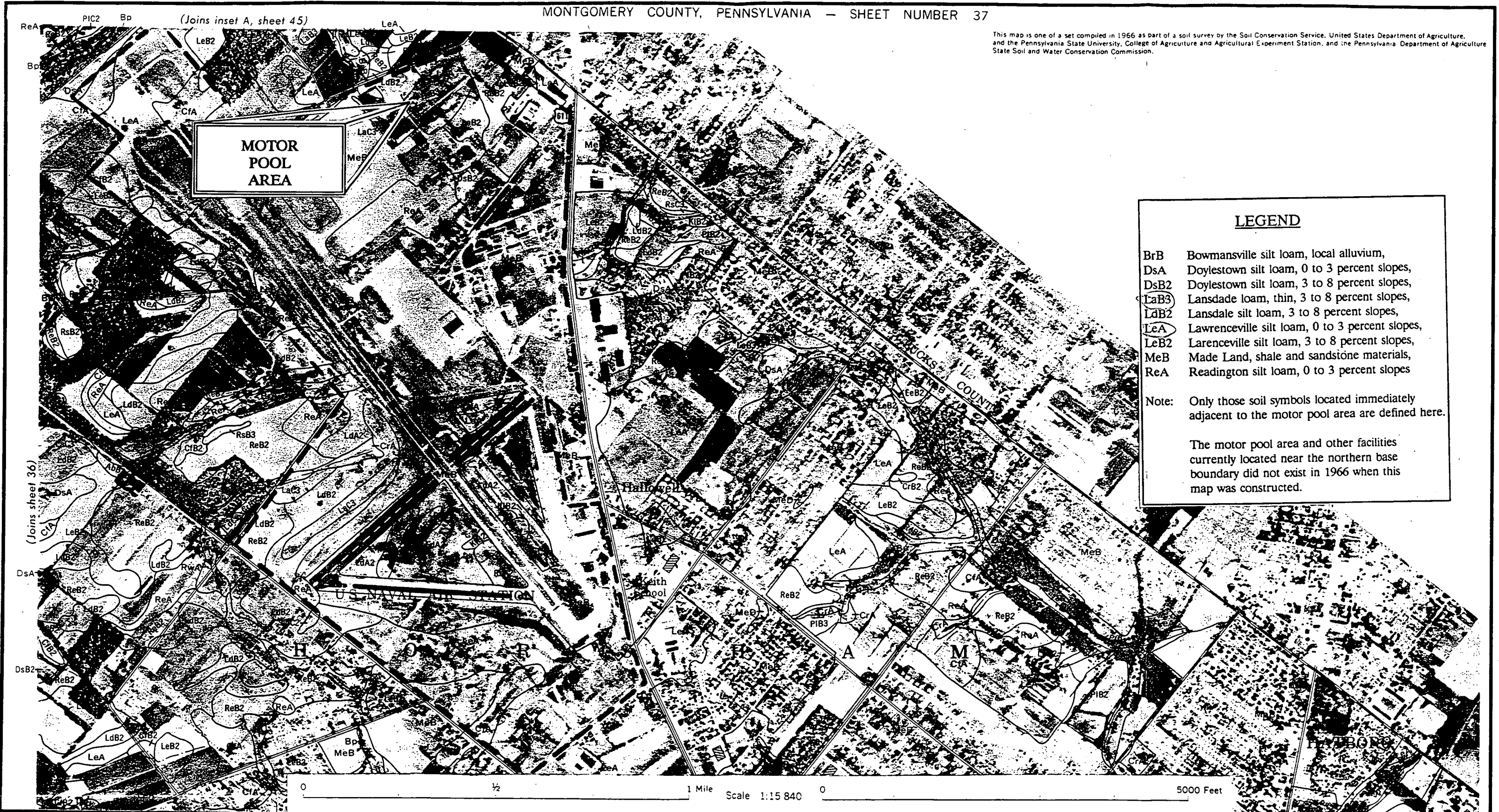
The underlying sedimentary bedrock is the Stockton Formation¹, which is the oldest of the three Triassic age geologic formations that make up the Newark Group. The Stockton Formation is composed mainly of very fine to coarse-grained arkosic sandstone and arkosic conglomerates with interbedded red shale and siltstone. Locally, sediments of different texture are interbedded with coarse-grained rocks overlying fine-grained rocks. Regionally, geologic beds in the Stockton Formation dip to the northwest in eastern Montgomery and Bucks County with beds pinching out or laterally grading into other lithologic facies. The geologic structure of the beds in the Stockton Formation dip from 5° to 18° to the northwest. The occurrence of faults within the Stockton Formation is common.⁴ Two parallel faults trending northeast to southwest have been identified approximately 3 miles northwest of the WGARS.¹

1.4.4 Soils

Soils overlying sedimentary bedrock at the Willow Grove ARS have been classified as MeB (Figure 1.7), which are areas that have been either disturbed, filled, or regraded to such an extent that natural soil properties have been greatly altered. Prior to the construction of Willow Grove ARS, these soils were probably either Lawrenceville Silt Loam (Le) or Lansdale Loam (La). Vertical permeabilities for Le soils and La soils are estimated to be 0.20 to 6.3 in. per hour (1.4×10^{-4} to 4.4×10^{-3} cm/s) and 0.63 to 6.3 in. per hour (4.4×10^{-4} to 4.4×10^{-3} cm/sec), respectively.⁵



This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Pennsylvania State University, College of Agriculture and Agricultural Experiment Station, and the Pennsylvania Department of Agriculture State Soil and Water Conservation Commission.



LEGEND

- BrB Bowmansville silt loam, local alluvium,
- DsA Doylestown silt loam, 0 to 3 percent slopes,
- DsB2 Doylestown silt loam, 3 to 8 percent slopes,
- LaB3 Lansdale loam, thin, 3 to 8 percent slopes,
- LdB2 Lansdale silt loam, 3 to 8 percent slopes,
- LeA Lawrenceville silt loam, 0 to 3 percent slopes,
- LeB2 Lawrenceville silt loam, 3 to 8 percent slopes,
- MeB Made Land, shale and sandstone materials,
- ReA Readington silt loam, 0 to 3 percent slopes

Note: Only those soil symbols located immediately adjacent to the motor pool area are defined here.

The motor pool area and other facilities currently located near the northern base boundary did not exist in 1966 when this map was constructed.

01	1/11/94		RDW	
R1	2/24/93		RDW	
R2	3/1/94			
r2	10/3/94	CH	TA	
NO.	DATE	REVISION	BY	CK. APPR.

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FIGURE 1.7 SOILS MAP
WILLOW GROVE AIR RESERVE STATION

SCALE: AS INDICATED

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1.4.5 Surface Water

Surface water from the WGARS and a portion of Willow Grove Naval Air Station (NAS) is diverted through surface drainage channels to the Ponding Basin (Figures 1.2 and 1.4). The Ponding Basin is a manmade catchment basin approximately 2.5 acres in area, with a capacity of 5.8 million gallons. A manually adjusted control gate regulates discharge from the basin according to the amount of rainfall and the rate of runoff. Discharge from the Ponding Basin flows northwestward, within an unnamed creek for approximately 2500 ft and then discharges into Park Creek. Park Creek flows to the northeast and discharges into Little Neshaminy Creek.

Surface water drainage in the field north-northwest of the Willow Grove NAS flows west-southwest toward the unnamed creek that flows north from the Ponding Basin. Aerial photographic interpretations and observations made during field investigations indicate a temporal stream path within the field that contains water during rainstorms. This temporal stream originates in an adjacent field to the north, and continues westwardly across off-base areas before discharging into the unnamed creek 500 ft downstream of the Ponding Basin.

The Graeme Historical Site (Figures 1.2 and 1.5), is located approximately 1500 ft downstream from the Ponding Basin and has two small ponds built in the unnamed stream. Discharge from the Ponding Basin enters these ponds before continuing downstream to Park Creek. Several additional ponds and lakes have been constructed by building small dams in the Little Neshaminy and Neshaminy Creeks, downstream of the Graeme Historical Site.¹

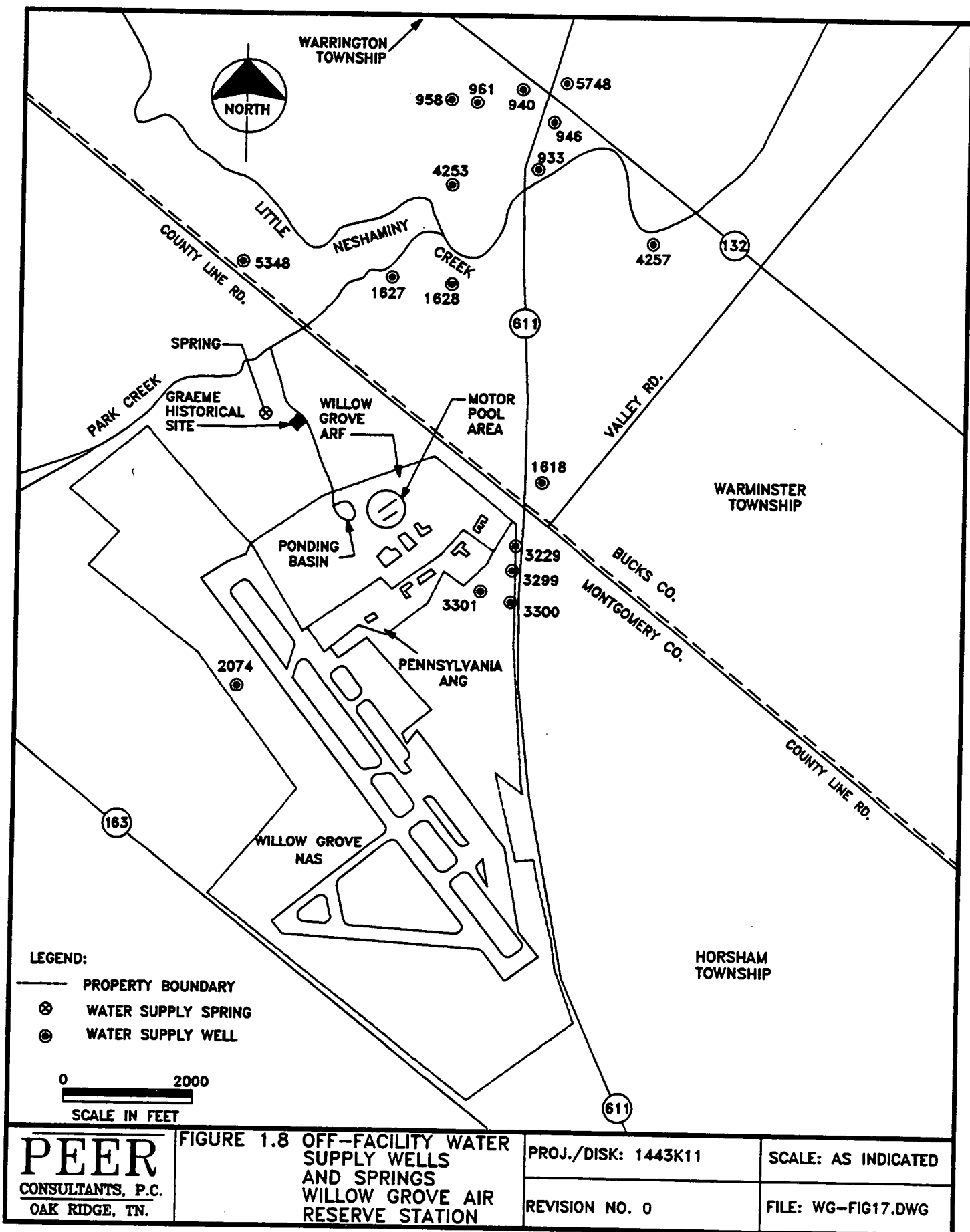
1.4.6 Groundwater

Groundwater beneath the WGARS occurs in both unconsolidated sedimentary deposits and the sedimentary bedrock. Groundwater in the unconsolidated sedimentary deposits is present under unconfined conditions. The seasonal high water table in the unconfined aquifer has been reported to be 1 to 2 ft below ground surface (BGS) for Le soils and greater than 3 ft BGS for La soils.

Groundwater beneath the WGARS generally flows toward the north-northwest in the unconsolidated sedimentary deposits. However, the Ponding Basin has a local influence on flow direction, as does the stream channel upon which the Ponding Basin was constructed. The Ponding Basin acts as a recharge zone when water level is at or near capacity, causing groundwater to flow from the basin. A local reversal in the groundwater table occurs when the level of water in the Ponding Basin is reduced. Under this condition, the Ponding Basin acts as a local discharge zone for groundwater from the water table aquifer in the unconsolidated sedimentary deposits.

Groundwater in the underlying Stockton Formation is generally under confined conditions. Groundwater occurs in pore spaces between the grains and in secondary porosity (such as fractures, joints, faults, and along bedding planes) in the rock. The size of the pore space between individual grains differs with the degree of sorting of the original sedimentary material and with the amount of cementation that binds the grains together. The middle arkosic member consists of well-sorted sandstone and is the best water-producing unit of the Stockton Formation.⁴

The Stockton Formation is a source of potable water in the area of WGARS. Potable water well depths in the area generally range between 300 and 600 ft BGS. An inventory of groundwater supply wells was conducted by D&M,¹ and 17 off-facility wells and 1 natural spring (used as a household water supply) were identified within a 1-mile radius of WGARS (Figure 1.7).



2.0 SITE ASSESSMENT

This section outlines the objectives of the SA conducted between October 18, 1993, and November 6, 1993, and in September 1994. A SA Work Plan (WP)⁶ was prepared and approved in January 1992. A Work Plan Addendum (WPA)⁷ was prepared and approved in September 1994. Work completed at the site conformed to the requirements of the WP and WPA.

2.1 SITE ASSESSMENT OBJECTIVES

The objectives of the SA were to determine the lateral and vertical extent of petroleum-related contamination in the vicinity of the Fuel Station Facility (Building No. 352) by completing a subsurface soil and groundwater investigation. Field activities were conducted in accordance with the WP and WPA, but were modified in response to the requirements in the final technical proposal and to site-specific conditions. Field changes were approved by the HAZWRAP and ANGRC Project Managers and the PEER Program Manager prior to implementation. Changes were documented on PEER Field Change Forms and copies of the complete forms are provided in Appendix B.

2.2 REGULATORY GUIDANCE

The Pennsylvania Department of Environmental Resources (PADER), Bureau of Water Quality Management (BWQM), has issued a guidance document⁸ for closure, site assessment and site remediation activities at UST sites (Appendix C). This PADER document is intended as a general guidance document outlining acceptable practices for owner/operators involved in closure or change-in-service of USTs.

→ This document is outdated

The PADER has established protective levels and criteria for the excavation, treatment, cleanup, and disposal of virgin fuel contaminated soil. The PADER guidance document "Protective Levels and Criteria for the Excavation, Treatment, Cleanup, and Disposal of Virgin Fuel Contaminated Soil," October 1991.⁹ provides practical field guidance for the implementation of these protective levels and criteria. The PADER has concluded that these Protection Levels are protective of human health and the environment and are also consistent with the Department's Ground Water Quality Protection Strategy. The PADER has identified three levels of protection (levels A, B, and C) which stipulate the disposition of petroleum contaminated soil. Level A represents the Department's most stringent Protection Level for the excavation, cleanup, treatment and disposal of virgin fuel contaminated soil (PADER, October 1991.⁹). Levels B and C are less stringent; however, the Department will impose more restrictive conditions on the management and disposal of Level B and C soils.

Because it was necessary to evaluate contaminant levels against a baseline action limit during the site assessment, it was decided that PADER's Level A Protection Levels for

BTEX and TPH would be used to define the extent of contamination at the site (refer to Field Change No. 1). The Level A Protection Limits for soil have been set at 0.01 mg/kg for benzene, 0.02 mg/kg for toluene, 0.02 mg/kg for ethylbenzene, and 0.07 mg/kg for xylenes. Level A Protection Limits for TPH concentrations in soil were set at 10 mg/kg (ppm). A limited number of benzene, toluene, ethylbenzene, and xylenes (BTEX) analyses completed on the initial soil samples indicated that BTEX constituents were of minor concern at this site. TPH constituents were found to be the primary contaminants of concern in the soil at this site, and this document therefore assesses the site based on the TPH Protection Level of 10 mg/kg.

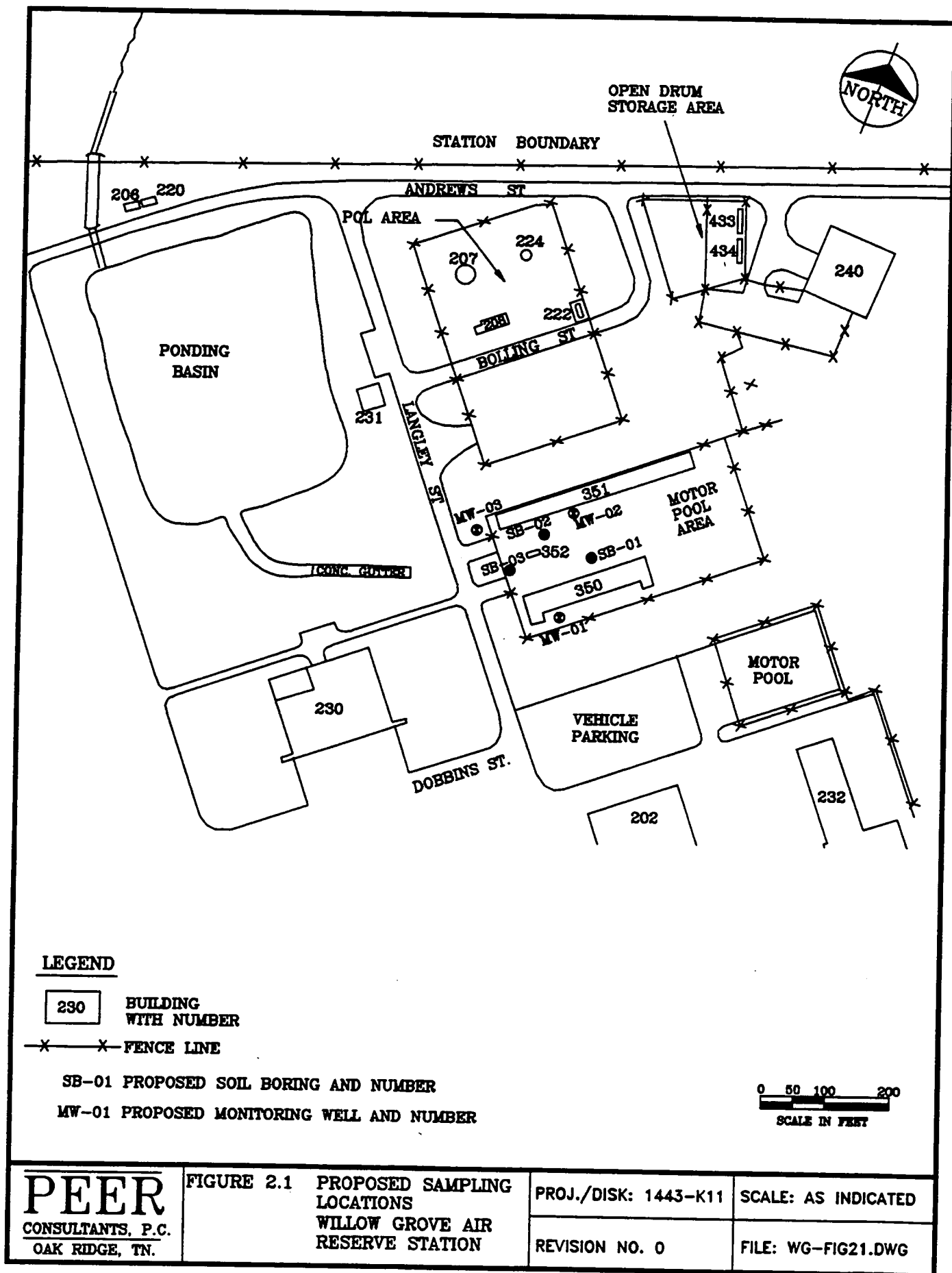
Action limits for groundwater are based on Pennsylvania Safe Drinking Water Regulations (PA 25 PCSR 109) or background levels.⁸ The state regulations incorporate the National Revised Primary and Secondary Drinking Water Regulations which have set the following maximum contaminant levels (MCLs): benzene, 0.005 mg/L; toluene, 1 mg/L; ethylbenzene, 0.7 mg/L; and total xylenes, 10 mg/L (40 CFR 141.61). No MCL exists for total petroleum hydrocarbons (TPH).

The PADER goal, with respect to soil and groundwater remediation, is to reduce contamination levels to background quality. However, where the owner/operator can demonstrate to PADER that background levels are technologically impossible or infeasible, PADER will require implementation of feasible technology that will achieve remediation levels as close to background as possible. At a minimum, the more stringent of health or environmentally based levels must be achieved. If the owner/operator demonstrates to PADER that contaminant levels cannot be reduced using available technology to established health-based or environmentally-based limits, PADER will require the owner/operator to achieve levels as close to health-based or environmentally-based limits as possible.

2.3 SITE ASSESSMENT APPROACH AND SCOPE

Initially, the scope of planned SA activities was described in the January 1992 WP. During the first phase of the SA, a minimum of three soil borings were to be advanced near the USTs to determine the horizontal and vertical extent of any soil contamination in the immediate vicinity (Figure 2.1). Based upon initial field screening results, additional soil borings were to be advanced, if necessary, to fully determine the extent of soil contamination. Additional soil borings were to be added with the prior concurrence of the PEER Program Manager and the HAZWRAP and ANGRC Project Managers.

During the second phase of the SA, three soil borings were to be advanced beyond the identified extent of soil contamination. Monitoring wells were to be installed in these borings to determine the presence and extent of groundwater contamination or free product, if any.



Specific tasks to be performed during the SA as specified in the WP included:

- advancing a minimum of six soil borings at the site and installing monitoring wells in three of the soil borings;
- obtaining soil samples continuously from each boring and obtaining groundwater samples from the three monitoring wells and two previously installed monitoring wells;

screening soil and water samples using a photoionization detector (PID) or organic vapor analyzer (OVA), and a field gas chromatograph (GC);
- developing each monitoring well after installation;

surveying the locations and elevations of the soil borings and monitoring wells;

obtaining water level and free product measurements (if any);

submitting selected soil and groundwater samples to a laboratory for analysis;
- documenting any additional task or work scope changes made; and

preparing a Site Assessment Report (this document) that includes the findings and recommendations of the investigation.

Following approval of the WP, and in response to the Statement of Work (SOW) dated April 13, 1993, a technical proposal dated April 14, 1993,¹⁰ was prepared under General Order No. 1GB-99170C and negotiations were conducted June 25, 1993. A revised technical proposal was submitted on July 7, 1993, and a Work Release was subsequently issued. The criteria stipulated in this technical proposal were utilized to carry out the field work performed at the WGARS.

Those tasks described in the technical proposal which differed from the WP are described below:

- after advancing the first three soil borings to refusal or to the saturated zone near the USTs, sequentially advancing and sampling another eight soil borings to refusal or to the saturated zone in order to determine the full extent of contamination at the site;
- advancing five soil borings beyond the contaminated zone, one upgradient and four downgradient, for the purpose of installing groundwater monitoring wells in the unconsolidated zone; and

- conducting slug tests in each of the new wells.

Other alterations to the work scope were made immediately before and during field observations. These alterations included air rotary drilling for the purpose of well installation because water was not encountered as expected in the unconsolidated deposits; and reducing the scope of laboratory analytical services to TPH analyses only for site soils after initial results indicated BTEX contaminants were generally not present. In each instance, field change forms were initiated to document these changes and were approved by the PEER Program Manager and the HAZWRAP and ANGRC Project Managers. The field change forms are included in Appendix B and the actual work performed to accommodate these changes is described under methodology (Section 2.4).

Results of the 1993 work allowed delineation of the north, west, and south extent of soil impacts to be determined. However, the limit of TPH contamination in the soil was not defined toward the northeast. *may have been!* Following discussion with HAZWRAP and the ANG, PEER mobilized to the site in order to install five additional soil borings in accordance with the WPA. The second mobilization occurred in September 1994.

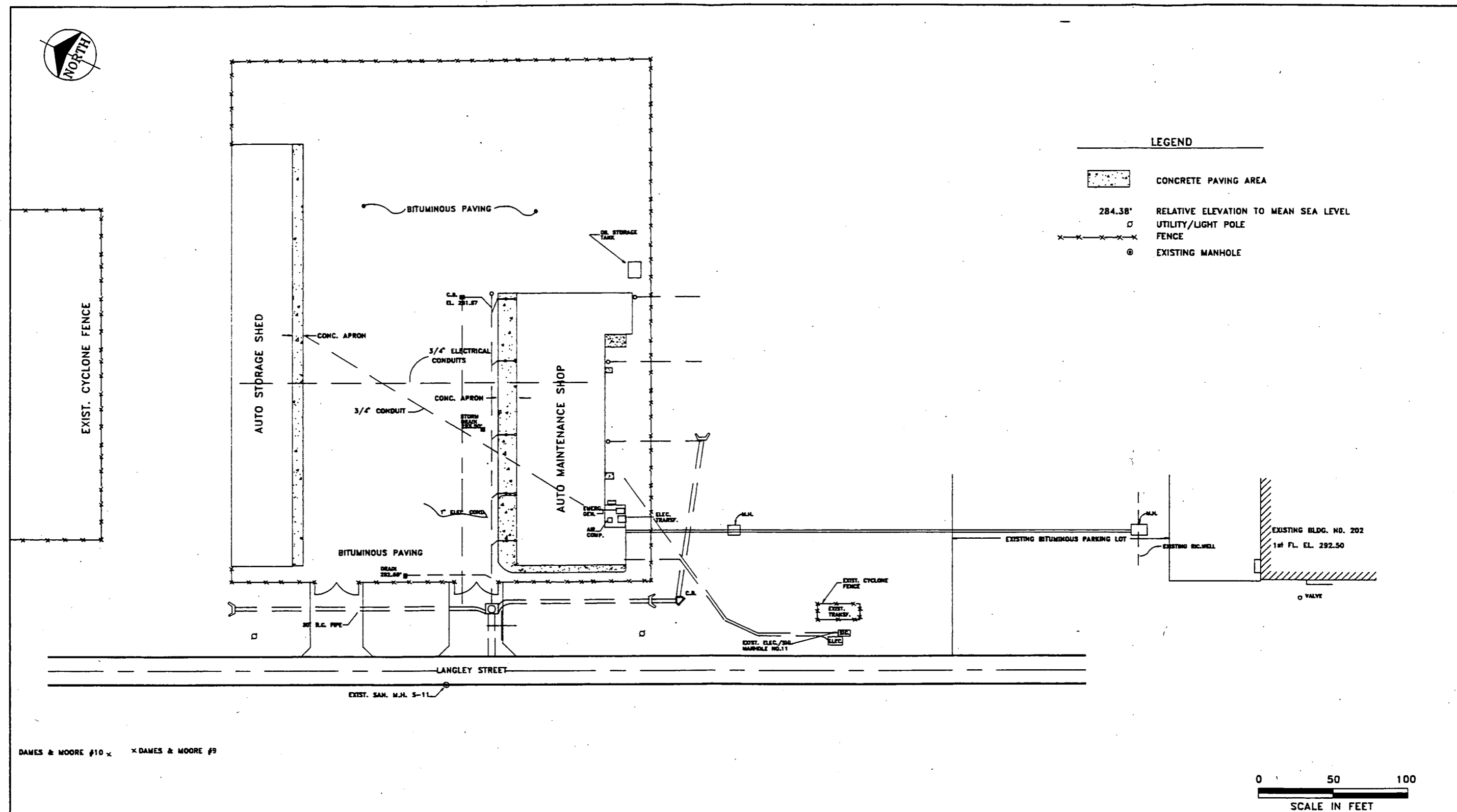
2.4 METHODOLOGY *2nd time*


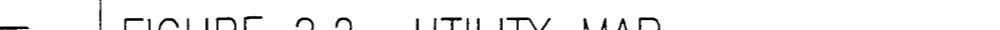
2.4.1 Utility Survey

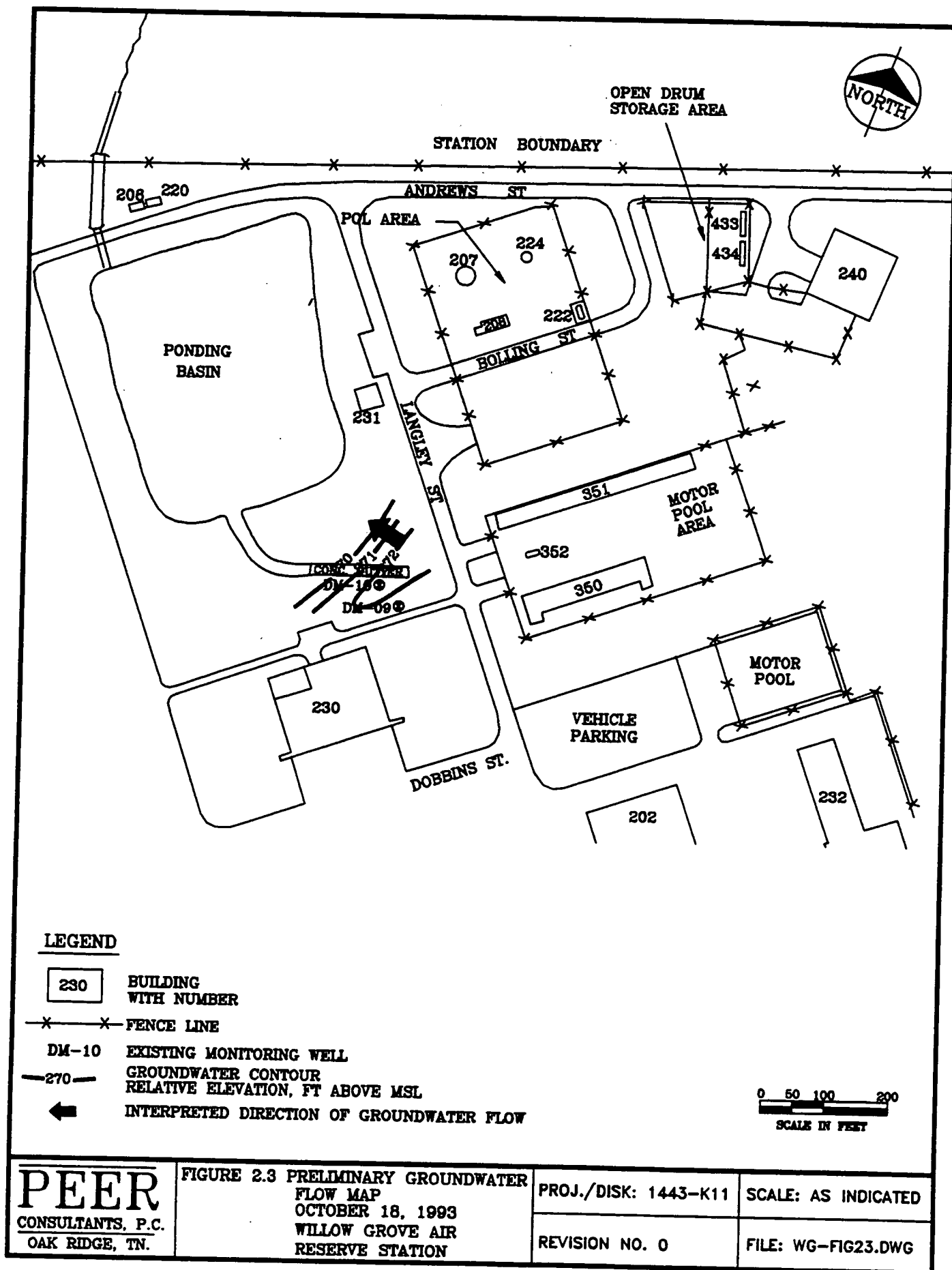
Proposed soil boring locations were marked using paint or stakes before drilling activities began. Areas in the vicinity of the borings were evaluated for the presence of aboveground and/or subsurface utilities. All subsurface utilities were identified by discussions with Air Force Reserve Station (AFRS) personnel and by contacting a local utility locating service (Figure 2.2). Telephone utilities were clearly marked to prevent damage during drilling. The drill rig was positioned to avoid overhead utility lines during drilling.

2.4.2 Groundwater Level Measurements

Prior to the drilling of the soil borings and installation of the monitoring wells, water level measurements were collected from the D&M RI monitoring wells MW-9 and MW-10 and the ponding basin to determine depths to groundwater and the groundwater flow direction. The water level in the Ponding Basin was surveyed using a surveyor's level and was referenced to the top of casing elevations obtained for the D&M monitoring wells. Depth to groundwater in the two RI monitoring wells was measured using an electronic water level tape calibrated in increments of 0.01 ft. This information was used to assist in the placement of SA soil boring/monitoring well locations. Figure 2.3 shows the groundwater contours and interpreted groundwater flow direction based on these measurements. Groundwater elevation measurements



01	1/11/94		RDW		<div style="text-align: center;">  <p>PEER CONSULTANTS, P.C.</p> </div>	<div style="text-align: center;">  <p>FIGURE 2.2 UTILITY MAP MOTOR POOL AREA WILLOW GROVE AIR RESERVE STATION</p> </div>		SCALE: AS INDICATED
R1	2/24/93		RDW					
R2	3/1/94							
			CH					
NO.	DATE	REVISION	BY	CK			APPR	
							DWN BY: S. DUNLAP	PROJ. NO: 1443K11
							REVISION NO. 2	FILE: SITE-WG.DWG



made in September 1994 were consistent with the 1993 measurements. Therefore, a separate potentiometric contour map was not prepared for the 1994 data.

2.4.3 Soil Borings

To determine the horizontal and vertical extent of soil contamination, a total of 31 soil borings were advanced at the MPA in accordance with the WP and WPA and Field Change No. 3 (Figure 2.4). Twenty-seven borings were installed during the implementation of the WP and five during the WPA. Soil borings were advanced to auger refusal, with the exception of SB-28, which was stopped at the water table. Four soil borings were continued by air rotary drilling (Field Change No. 2) into the bedrock to evaluate the potential for groundwater contamination in the bedrock, because groundwater was not encountered in the unconsolidated deposits as originally expected.

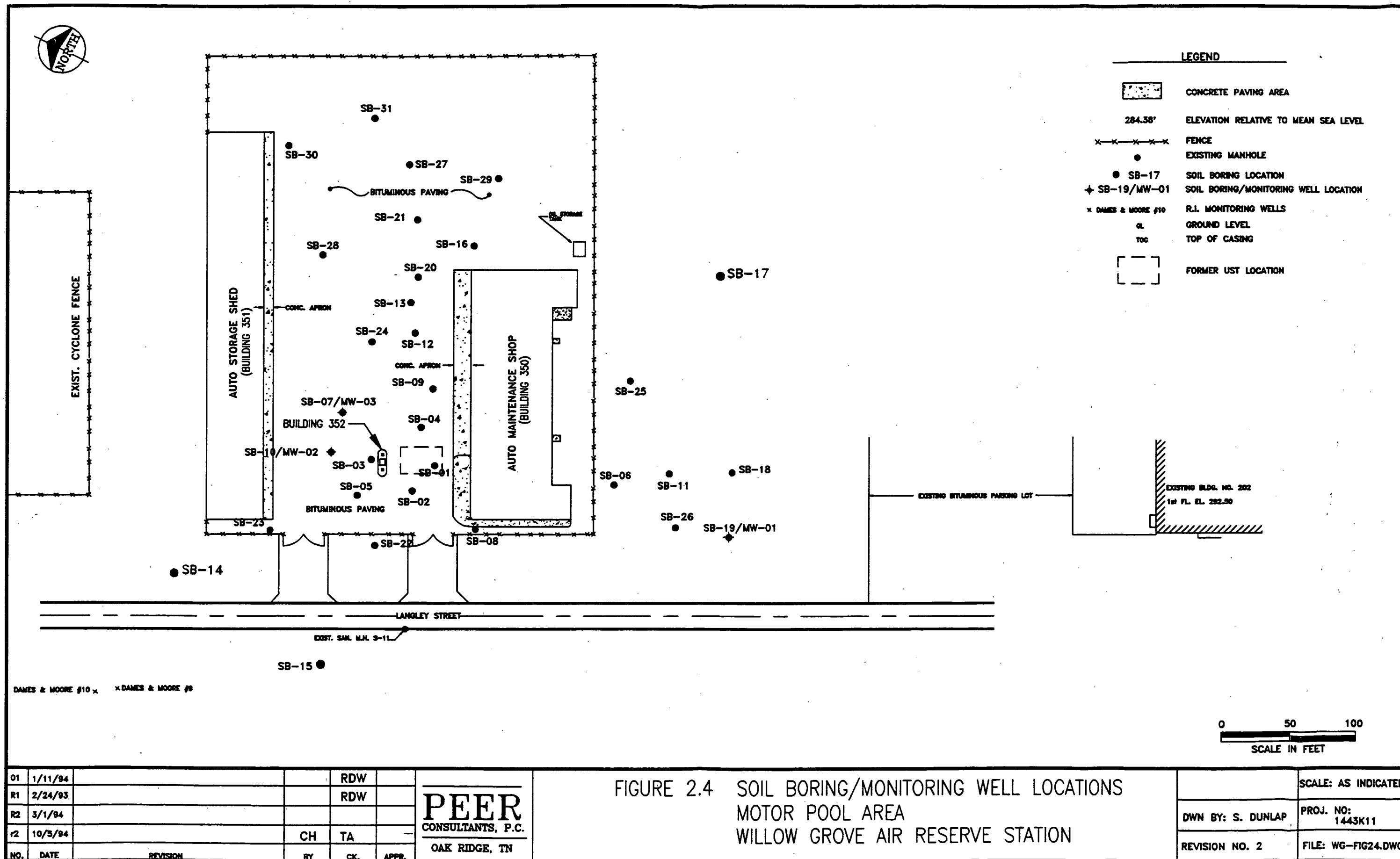
The proposed locations of the soil borings as described in the WP are shown in Figure 2.1. The actual locations of all soil borings following implementation of the field changes are shown on Figure 2.4. Soil borings were designated as "contaminated" or "clean" based upon the field GC results. These field data provided a basis for installing additional soil borings during implementation of the WP. Rationale for placement of the borings is as follows.

SB-01 was advanced on October 19, 1993, to a total depth of 13 ft BGS. It was located on the southeast side of the UST excavation to determine whether or not contamination existed in that direction.

SB-02 was advanced on October 19, 1993, to a total depth of 8 ft 11 in. BGS. It was located on the southwest side of the UST excavation to determine whether or not contamination existed in that direction.

- SB-03 was advanced on October 19, 1993, to a total depth of 10 ft BGS. It was located on the northwest side of the UST excavation to determine whether or not contamination existed in that direction.
- SB-04 was advanced on October 19, 1993, to a total depth of 10 ft BGS. It was located on the northeast side of the UST excavation to determine whether or not contamination existed in that direction.

SB-05 was advanced on October 20, 1993, to a total depth of 9 ft 10 in. BGS. It was located west of SB-02 and SB-03 due to the presence of TPH contamination in these two borings. SB-05 was later advanced to 25 ft BGS on October 21, 1993, at the direction of HAZWRAP, utilizing an air rotary rig to



determine the depth of groundwater and the potential of groundwater contamination hydraulically downgradient of the UST area. Air rotary drilling was addressed in Field Change No. 2.

- SB-06 was advanced on October 20, 1993, to a total depth of 7 ft BGS. It was located on the south side of Building 350 due to the presence of TPH contamination in SB-01.

SB-07 was advanced on October 21, 1993, to a total depth of 8 ft 11 in. BGS. It was located north of SB-03 and SB-04 due to the presence of TPH contamination in these borings. This soil boring was continued using air rotary drilling to 26 ft BGS (into bedrock) and was converted to MW-03.

- SB-08 was advanced on October 25, 1993, to a total depth of 10 ft BGS. It was located near the northwest corner of Building 350 due to the presence of TPH contamination in SB-01 and SB-02.

SB-09 was advanced on October 25, 1993, to a total depth of 11 ft 11 in. BGS. It was located east of SB-04 due to the presence of TPH contamination in SB-04.

SB-10 was advanced on October 25, 1993, to a total depth of 7 ft 8 in. BGS. It was located north of SB-03 due to the presence of TPH contamination in SB-03. This boring was extended using air rotary drilling to a depth of 26 ft BGS (into bedrock) and was converted to MW-02.

- SB-11 was advanced on October 25, 1993, to a total depth of 8 ft BGS. It was located southeast of SB-06 due to the presence of TPH contamination in SB-06.
- SB-12 was advanced on October 25, 1993, to a total depth of 11 ft 10 in. BGS. It was located east of SB-09 to further identify the extent of soil contamination to the east.

SB-13 was advanced on October 28, 1993, to a total depth of 12 ft BGS. It was located east of SB-12 due to the presence of TPH contamination in SB-12.

- SB-14 was advanced on October 28, 1993, to a total depth of 5 ft 10 in. BGS. It was located northwest of SB-05 and outside of the fenced area to attempt to find the extent of soil contamination to the northwest.

SB-15 was advanced on October 28, 1993, to a total depth of 7 ft 11 in. BGS. It was located west of SB-05 and across Langley Street in order to determine the extent of contamination to the west.

SB-16 was advanced on October 28, 1993 to a total depth of 12 ft BGS. It was located east of Building 350 in order to determine the extent of contamination to the east.

SB-17 was advanced on October 28, 1993, to a total depth of 7 ft BGS. It was located south of Building 350. Its purpose was to find the extent of soil contamination to the southeast of the MPA.

SB-18 was advanced on October 28, 1993, to a total depth of 7 ft 3 in. BGS. It was located south of SB-11 due to the presence of TPH contamination in SB-11.

SB-19 was advanced on October 28, 1993, to a total depth of 6 ft BGS. It was located south of Building 350. Its purpose was to determine the extent of contamination to the southwest of the MPA. This soil boring was extended to 26 ft BGS (into bedrock) and was converted to monitoring well MW-01.

- SB-20 was advanced on November 1, 1993, to a total depth of 11 ft 9 in. BGS. It was located east of SB-13 due to the presence of TPH contamination in SB-13.

SB-21 was advanced on November 1, 1993, to a total depth of 11 ft 11 in. BGS. It was located east of SB-20. Its purpose was to define the limit of soil contamination to the southeast of the MPA.

SB-22 was advanced on November 4, 1993, to a total depth of 8 ft BGS (Field Change No. 3). Its purpose was to define the limit of soil contamination between SB-02, which was contaminated, and SB-15, which was not contaminated.

SB-23 was advanced on November 4, 1993, to a total depth of 8 ft BGS (Field Change No. 3). Its purpose was to define the limit of soil contamination between SB-05, which was contaminated, and SB-14, which was not contaminated.

SB-24 was advanced on November 4, 1993, to a total depth of 10 ft BGS (Field Change No. 3). It was located north of SB-09 in order to define the limit of soil contamination to the north.

SB-25 was advanced on November 4, 1993, to a total depth of 5 ft 11 in. BGS (Field Change No. 3). It was located east of SB-06 in order to define the limit of soil contamination to the southeast.

SB-26 was advanced on November 4, 1993, to a total depth of 7 ft 1 in. BGS (Field Change No. 3). It was located between SB-06 and SB-19 to define the limit of soil contamination to the southwest of the MPA.

- SB-27 was advanced on September 28, 1994, to a total depth of 13 ft BGS. It was located 40 ft northeast of soil boring SB-21 to define the limit of soil contamination northeast of SB-21.
- SB-28 was advanced on September 28, 1994, to a total depth of 18 ft BGS where water was encountered. It was located 66 ft north of SB-20 to define the limits of contamination (if any) north of borings SB-20 and SB-21.
- SB-29 was advanced on September 29, 1994, to a total depth of 7.5 ft BGS. It was located 66 ft east of soil boring SB-16 in order to continue the delineation of contaminated soils to the southeast of soil boring SB-21.

SB-30 was advanced on September 29, 1994, north of soil boring SB-27 and was intended to intercept any soil contamination that may exist in the area due to groundwater transport of contaminants. It was located 86 ft north of SB-27 and was installed to a depth of 14 ft BGS.

- SB-31 was advanced on September 29, 1994, northeast of soil boring SB-27 and was intended to continue the line of investigative borings SB-13, SB-20, SB-21, and SB-27. This boring was intended to delineate the northeasternmost limits of any soil contamination. Soil boring SB-31 was installed to a depth of 11 ft BGS.

Soil cuttings from each soil boring were contained in Department of Transportation (DOT) specification removable top steel drums for disposal by the ANG.

2.4.4 Soil Sampling

Soil borings were generally advanced through the unconsolidated deposits using a hydraulically-activated drill rig equipped with 4.25-in. inside diameter (I.D.) hollow stem augers (HSAs). Soil borings SB-22, SB-23, and SB-24 were advanced with an air rotary drill rig. Soil borings were advanced to refusal, in accordance with the approved WP, with the exception of SB-28, which was advanced to where water was first encountered. The soils were continuously sampled at 2-ft intervals from the ground surface to refusal. In instances where the soil boring location was overlain by asphalt, the driller was instructed to auger through the pavement and fill material, thoroughly clean out the hole, and begin sampling at a depth of 2 ft BGS. Samples were collected using 2-ft-long split-spoon samplers in accordance with American Society for Testing and Materials (ASTM) Method D1586-84. Soil samples were

visually classified in the field by a qualified geologist in accordance with ASTM-2488-90 specifications.

Immediately upon opening the split spoon, the soil core was divided into two portions. The sample portion exhibiting the highest possible potential for contamination (i.e., staining, odors, OVA reading) was designated for laboratory analysis, and was placed into a 4-oz. widemouth glass jar supplied by the laboratory. Sample jars were supplied with a Teflon™ lined lids. As little headspace as possible was left in the sample jar. The sample portion exhibiting the least potential for contamination was designated for headspace analysis and was placed into a glass jar. The mouth of the jar was covered with aluminum foil leaving some airspace, and capped.

A separate soil sample aliquot was weighed into a 40 mL septa capped vial for the GC sample. Care was taken to ensure that the sample aliquot was representative of the split spoon sample. The extraction liquid was added to the vial, then the vial was tightly capped. The GC procedure is detailed in Appendix D.

Care was taken to collect soils which were free of plant matter, asphalt, and gravel. After sample collection, the sample containers were wiped clean with a paper towel and packed in a cooler with double bagged water ice. Samples were maintained at 4°C after collection. A minimum of two samples from each boring was submitted for laboratory analysis. Additional samples were selected for laboratory analysis at the discretion of the site manager.

2.4.5 Shelby Tube Sampling

Two Shelby tube samples were obtained of the unconsolidated deposits from soil borings SB-13 and SB-14 using a thin wall (Shelby tube) sampler. Shelby tube samples was obtained from 6 to 8 ft BGS and 4 to 6 ft BGS in soil borings SB-13 and SB-14, respectively. Each Shelby tube was advanced using the hydraulically-activated drill rig to push the Shelby tube into the soil.

The ends of the Shelby tubes were sealed using melted paraffin wax in order to prevent release of moisture and the formation of desiccation cracks in the samples. The ends of each tube were then sealed with duct tape, and the Shelby tube was labeled. Samples were submitted to a geotechnical laboratory for coefficient of permeability analysis by ASTM Method D2434.

2.4.6 Field Screening

— why?

Field headspace screening was conducted on all soil samples collected during the 1993 and 1994 sampling events. Samples for headspace analysis were allowed to equilibrate (volatilize) above a minimum temperature of 68°F for at least 15 minutes. Air temperature was verified using a thermometer. All samples were allowed to

equilibrate for the same length of time. Once the sample had equilibrated, headspace was screened for the presence of ionizable organic vapors using either a Foxboro Model 128 OVA or a HNu PID. The PID was used during the 1994 field work. The instrument probe was inserted through the foil under the lid of the jar and a reading of headspace organic vapors was made and recorded in the field logbook. Headspace results for the 1993 and 1994 sampling events are presented in Appendix E.

2.4.7 Field Gas Chromatography Screening

Sample portions for static headspace analysis were collected and allowed to gain thermal and phase equilibrium in a waterbath at a temperature of 110°F. Headspace samples were analyzed by withdrawing a known headspace volume and injecting the volume in the field GC for analysis. Target compound retention times were then compared to calibrated target compound retention times for each compound to obtain approximate concentrations. The specific field GC method is given in Appendix D. Field GC screening was not utilized during the 1994 sampling.

2.4.8 Analytical

To satisfy PADER requirements, the contaminated soils were characterized by using the recommended analytical methods specified in the "Staff Guidance for Underground Storage Systems in Pennsylvania" (Appendix C). For the site assessment, the PADER documents specified the analytical methods that were used. Soil samples were analyzed for BTEX constituents using EPA analytical Method 8020, and for TPH using EPA analytical Method 418.1. Water samples were analyzed for BTEX constituents using EPA analytical Method 602 and for TPH using EPA analytical Method 418.1 (Table 2.1). Copies of the laboratory analytical reports are contained in Appendix F, and the results are summarized in Section 3.4.

2.4.9 Soil Boring Abandonment

Borings which were installed during the SA and not converted to monitoring wells were abandoned by grouting. The grout consisted of a mixture of Portland cement and 4 to 6% powdered bentonite. A grout density of 13.5 to 14.1 lbs/gal was used. The grout was emplaced until it completely filled the borehole. Abandoned borings in the asphalt paved area were topped off with cold patch asphalt material.

2.4.10 Monitoring Well Installation

Groundwater monitoring wells MW-01, MW-02, and MW-03 were installed in three previously drilled soil borings (SB-19, SB-10, and SB-07, respectively). In each case, an air rotary rig was utilized to reenter the previously drilled soil boring in order to penetrate into bedrock and encounter groundwater. The location of each monitoring

TABLE 2.1
SUMMARY OF NUMBER OF SAMPLES, ANALYTICAL METHODS,
CONTAINER TYPES, AND PRESERVATIVES FOR WILLOW GROVE AIR RESERVE STATION¹

Sample Location	Parameter	Analytical Method	No. of Laboratory Samples	Duplicates	Container Type	Preservative Requirements
Borings	BTEX	8020	10	1	40-mL glass vials (2)	Cool 4°C
	TPH	418.1	63	6	4-oz. glass jar	Cool 4°C
Monitoring Wells, Equipment Rinsates, and Blanks	BTEX	602	12	1	40-mL glass vials (2)	Cool 4°C, HCl
	TPH	418.1	12	1	905 mL amber	Cool 4°C
Trip Blanks	BTEX	602	9	0	410-mL glass vials (2)	Cool 4°C, HCl

¹ Numbers shown are actual numbers of samples which were analyzed.

well was designated under the direction of HAZWRAP representatives. The purpose of the monitoring wells was to determine potential petroleum contaminant concentrations in groundwater within the bedrock, the direction of groundwater flow within bedrock, and the horizontal hydraulic gradients within the bedrock aquifer.

Monitoring wells were constructed in the 6-in. diameter open holes using 16 ft of 2-in. I.D. Schedule 40 polyvinyl chloride (PVC) well screen with 0.01-in. slots. A 2-in. I.D. Schedule 40 PVC flush thread riser pipe was installed from the top of the well screen to the ground surface. Care was taken to ensure that the well was centered in the borehole before the sand pack was added. A clean, fine-grained silica sand was placed in the annulus around the well screens and extended to at least 1 ft above the well screen in each well.

A bentonite pellet seal at least 1 ft thick was placed above the sand pack in each well. Bentonite pellets were placed in the annular space around the PVC riser and hydrated using distilled water if groundwater was insufficient to hydrate the pellets. The remainder of the annular space was filled with cement/bentonite grout after allowing the pellets to hydrate for 1 hour. After the grout set, a 12-in. diameter flush-mounted curb box was placed over each well and locking well caps were placed on the PVC riser pipes.

2.4.11 Site Survey

The location and elevation of soil borings, monitoring wells, and other site features were surveyed between October 18 and November 5, 1993, and September 30, 1994. The locations of monitoring wells and soil borings were established by measuring the distances from each monitoring well/soil boring to existing structures at the site to the nearest 0.01 ft utilizing a surveyor's level. Relative elevations of the monitoring wells [top of casing (TOC) and ground surface] and soil borings (ground surface) were determined by differential leveling utilizing a surveyor's level. All elevations used in the site survey were measured relative to an established benchmark at the west outside corner of the auto maintenance shop. A summary of the relative survey elevations is included in Table 2.2.

2.4.12 Groundwater Level and Free Product Measurements

Groundwater elevations were measured in the existing monitoring wells (DM-9 and DM-10), soil boring SB-05, and newly installed monitoring wells (MW-01, MW-02, and MW-03) to the nearest 0.01 ft using an electric oil/water interface probe that was decontaminated between measurements. Elevations were referenced to TOC in each well. No free product was noted in any of the existing monitoring wells. A summary of groundwater elevations is presented in Table 2.2.

TABLE 2.2
SUMMARY OF REFERENCE LOCATION, RELATIVE ELEVATIONS, AND
RELATIVE GROUNDWATER ELEVATION DATA,
WILLOW GROVE AIR RESERVE STATION

Reference Location	Reference Elevation TOC/Land Surface	Relative Groundwater Elevations				
		10/18/93	10/20/93	10/26/93	11/6/93	9/29/94
DM-9	284.55'	271.89'	271.83'	272.10'	NM	NM
DM-10	284.82	277.40'	272.22'	272.53'	NM	NM
POND	269.55'	269.55'	267.71'	269.92'	NM	NM
MW-01	284.04'	NI	NI	NI	277.57'	277.46'
MW-02	285.06'	NI	NI	NI	272.82'	271.90'
MW-03	284.26'	NI	NI	NI	272.23'	271.25'
SB-01	284.66'	NI	273.56'	NM	NM	NM
SB-02	284.27'	NI	NW	NW	NW	NM
SB-03	284.98'	NI	NW	NW	NW	NM
SB-04	284.26'	NI	NW	NW	NW	NM
SB-05	284.07'	NI	NW	273.27'	NM	NM
SB-06	284.45'	NI	NW	NW	NW	NM
SB-07	285.09'	NI	NI	NW	NW	NM
SB-08	284.44'	NI	NI	NW	NW	NM
SB-09	283.61'	NI	NI	NW	NW	NM
SB-10	285.28'	NI	NI	NW	NA	NM
SB-11	283.87'	NI	NI	NW	NW	NM
SB-12	284.07'	NI	NI	NW	NW	NM
SB-13	284.48'	NI	NI	NI	NW	NM
SB-14	281.36'	NI	NI	NI	NW	NM
SB-15	283.12'	NI	NI	NI	NW	NM
SB-16	284.33'	NI	NI	NI	NW	NM

TABLE 2.2 (continued)
SUMMARY OF REFERENCE LOCATION, RELATIVE ELEVATIONS, AND
RELATIVE GROUNDWATER ELEVATION DATA,
WILLOW GROVE AIR RESERVE STATION

Reference Location	Reference Elevation TOC/Land Surface	Relative Groundwater Elevations				
		10/18/93	10/20/93	10/26/93	11/6/93	9/29/94
SB-17	283.44'	NI	NI	NI	NW	NM
SB-18	283.80'	NI	NI	NI	NW	NM
SB-19	284.16'	NI	NI	NI	NA	NM
SB-20	283.76'	NI	NI	NI	NW	NM
SB-21	284.28'	NI	NI	NI	NW	NM
SB-22	283.34'	NI	NI	NI	NW	NM
SB-23	285.03'	NI	NI	NI	NW	NM
SB-24	284.93'	NI	NI	NI	NW	NM
SB-25	282.48'	NI	NI	NI	NW	NM
SB-26	284.12'	NI	NI	NI	NW	NM
SB-27	285.25	NI	NI	NI	NI	NW
SB-28	285.55'	NI	NI	NI	NI	268.55'
SB-29	284.53'	NI	NI	NI	NI	NW
SB-30	285.83'	NI	NI	NI	NI	NW
SB-31	285.50'	NI	NI	NI	NI	NW

DM - Dames & Moore
MW - monitoring well
NA - not applicable
NI - not installed at time of static water level measurement
NW - no water encountered
NM - not measured
SB - soil boring

All measurements in feet above sea level.

2.4.13 Monitoring Well Development

Groundwater monitoring wells were developed after installation on November 5, 1993, by bailing with disposable Teflon™ bailers. Temperature, pH, and conductivity were monitored during well development for each well volume removed. Wells were considered to be developed when the development water was clear of visible suspended sediments and when the field parameters had stabilized within $\pm 10\%$ for consecutive readings. The number of well volumes removed from monitoring wells during development ranged from 2 (MW-03) to 4 (MW-01) well volumes. Development water was containerized in steel DOT specification removable-head drums for later disposal by the ANG. why?

2.4.14 Groundwater Sampling

Purging of the monitoring wells (MW-01 through MW-03) was conducted on November 6, 1993. Wells were purged using disposable Teflon™ bailers by removing three well volumes from the well. Conductivity, temperature, and pH were monitored during the purging of each well. Purging was considered complete when monitoring measurements stabilized to within $\pm 10\%$ of previous readings. Well purging data sheets are presented in Appendix G. Purge water was contained in DOT specification steel drums for later disposal by the ANG. *conflicting requirements*

Following purging, groundwater samples were collected for laboratory analysis from the newly installed monitoring wells MW-01, MW-02, and MW-03 on November 6, 1993. Groundwater samples were collected using disposable Teflon™ bailers attached to new polypropylene rope. During sample collection, the bailer was lowered gently to the water, to avoid unnecessary agitation of the well water. This process avoided aerating the samples and reduced the amount of sediment entrained in the sample.

Samples were transferred from the bailers to the sample containers carefully to avoid entraining air bubbles in the samples. Particular care was taken to avoid including any air bubbles in the 40 mL vials. Water samples were containerized into laboratory supplied 40-mL vials for BTEX analysis and 950 mL amber glass jars for TPH analysis. A duplicate water sample was obtained from MW-03 for one analytical laboratory quality check. Water samples were placed in a cooler with double bagged ice (4°C) and picked up by laboratory personnel following chain-of-custody (COC) procedures. Copies of completed COC forms are included in Appendix H.

2.4.15 Hydraulic Conductivity Tests

Rising head field tests ("slug tests") were performed in monitoring wells MW-01, MW-02, and MW-03 on November 6, 1993, to evaluate the hydraulic conductivity of the water-bearing deposits in the screened interval of the wells. Water was bailed from each well and the rate of water level recovery was monitored using an electric oil/water

not the correct way

*No wonder! One
could never bail fast
enough! DA!*

interface probe. Approximately 18 gal were bailed from each well. However, the water levels did not decrease sufficiently in order to monitor the rate of recovery. The water levels decreased by only 0.09 ft in MW-01, and 0.02 ft in MW-03. The water level could not be drawn down in MW-02. The rate of recovery was measured in each well until static water level was reached. Data from these tests proved insufficient to determine the hydraulic conductivity of the bedrock aquifer at each well, although it can be concluded from this response that the aquifer is fairly conductive.

2.4.16 Field Logbook

Field logbook documentation was completed in accordance with PEER Standard Operating Procedure (SOP) F-1, "Field Logbook." The field logbook was used for recording field information pertaining to all Contractor and Subcontractor activities performed during the site assessment, including field work documentation, field instrument calibration, field instrumentation readings, photographic references, sample numbers, field descriptions, equipment used, and field activities accomplished. Entries included sufficient detail to reconstruct significant activities without reliance on memory. All measurements and samples collected were noted and initialed in the margin at that time by the individual responsible for the entry.

The field logbook was bound and contained sequentially numbered pages. All entries were written in waterproof ink. The following information was included in the field logbook:

- Date and time each task started; weather conditions; names, titles, and organizations of personnel performing the task.
- A description of site activities in specific detail.
- A description of field screening activities in detail, including instrument calibration.
- A description in specific detail of samples collected, sample identification numbers, and COC form numbers.
- A list of the time, equipment type, and decontamination procedures followed (if different from WP).
- A list of equipment failures or breakdowns and description of repairs.
- Any field changes or additional work added to the WP.

Each page was dated and signed by the person making the entry. Incorrect entries were corrected by drawing a single line through the error, and initialing it.

2.4.17 Instrument Calibration

All field instruments were calibrated at least once daily according to manufacturer's instructions. Each instrument calibration was documented in field logbook.

The portable OVA used for screening for the presence of organic vapors was calibrated using 100 ppmv methane gas. The portable GC used for screening for the presence of BTEX constituents in soil was calibrated using 2000 $\mu\text{g/mL}$ BTEX in methanol standard solution. The HNu system PID was calibrated using 100 ppmv isobutylene gas. All calibrations were performed in accordance with the manufacturer's instructions using the calibration standards recommended by the manufacturer.

2.4.18 Sample Designation

All samples collected were assigned a unique sample number in accordance with PEER SOP F-2 as described below:

- 2-character code representing the collection location of the sample (e.g., for soil boring, SB = boring; for discrete pits, PF = pit floor, EW = east wall, WW = west wall, NW = north wall, SW = south wall; for piping trenches, PT = piping trench; for test pits, UE = tank end/piping trench junction, DE = dispenser end/piping trench junction; for soil stockpiles, SP = stockpile);
- 2-digit number representing the coordinate locations for samples from borings, soil stockpiles, or trenches; and
- for soil samples, a 2-digit number representing the depth of the sample BGS in ft. The number will correlate to the sampling interval shown on the boring logs.

For example, SB-01-08 represents a soil sample obtained from soil boring number 01 at a depth interval of 6 to 8 ft BGS.

2.4.19 Sample Containers, Labels, and Preservation

Sample containers were new and precleaned and were provided by the analytical laboratory. Sample volume requirements, preservation techniques, maximum holding times, and container material requirements were dictated by the media being sampled and the analyses to be performed (Table 2.1). Samples were contained in appropriate containers, with the preservatives as necessary, to allow for all the scheduled analyses to be completed for each sample.

The sample labels were supplied with the containers. A unique sample number was assigned to each sample immediately upon collection, as described in Section 2.4.18.

2.4.20 Sample Packaging and Shipment

Samples were packed and shipped in accordance with PEER SOP F-3, "Packaging and Shipment of Environmental Samples," within 24 hours of collection. Samples were preserved the same day they were collected. Coolers were shipped by a next-day delivery service to the laboratory. Notification of shipment, including airbill number, was telephoned to the laboratory the day of sample collection. Receipt of the previous day's shipment was confirmed daily. All sample containers, preservatives, and shipping crates/coolers were supplied by the designated analytical laboratory.

Immediately upon collection, samples designated for laboratory analysis were placed in a shipping container at the point of collection and surrounded with double-bagged water ice so that the temperature of the samples was maintained at 4°C. Packing material was used to secure the samples in the shipping container to prevent breakage of glass containers. The COC form (Section 2.5.3) was placed in a plastic cover and taped inside the lid of the shipping container. The lid of the container was then closed, secured using strapping tape, and custody sealed to ensure that samples were not disturbed during shipment.

2.5 QUALITY ASSURANCE AND QUALITY CONTROL

PEER SOPs covering documentation, sample collection, handling and packaging, quality control samples, and sample custody were followed throughout implementation of the field program. Portions of the Quality Assurance (QA)/Quality Control (QC) Program are summarized in the following subsections.

2.5.1 Field Changes

All field activities were conducted in accordance with the WP, with the exception of modifications or changes which occurred after the approval of the WP and WPA. The changes included discussions with PADER regarding target levels for soil or field responses to site-specific field conditions. Field changes were made in accordance with PEER Quality Assurance Procedure (QAP)-001G, "Control of Field Changes," and were approved by the PEER Program Manager and the HAZWRAP and ANGRC Project Managers prior to initiation. All changes were documented in the field logbook, and on PEER Field Change Forms (Appendix B).

2.5.2 Data Reporting

Data quality and data validation were controlled in accordance with PEER QAP-002D, "Control of Data Quality and Data Validation." This ensured that field data gathered or developed were properly reviewed and were of acceptable quality for their intended use.

2.5.3 Chain-of-Custody (COC)

Chain-of-custody was maintained from the time of sample collection through analysis. All samples collected for off-site laboratory analysis during the monitoring program were documented on a COC Form. The original COC Form accompanied all samples from the time of collection through laboratory receipt. Copies were maintained by the PEER Site Manager. Each custody transfer was documented by signature of the relinquishing and receiving individuals, and the date and time of transfer. Copies of the completed COC Forms are included in Appendix H.

COC procedures were used throughout the site assessment to guide the transmittal of collected samples to the analytical laboratory, and other necessary parties. Samples were considered to be under custody if:

- they were in the sampler's possession, or
- they were in the sampler's line of sight after being in possession, or
- they were in a designated controlled source area.

The Site Manager had overall responsibility for ensuring that care and custody of the samples collected were maintained until they were transferred or properly dispatched to the laboratory. Each individual who collected a sample was responsible for sample custody until transferred to someone else via the COC record.

The samples for field screening and classification remained in the possession of the field team from collection through analysis. A PEER COC form was completed for all samples submitted to an off-site laboratory for analysis. The COC form documented the following information: project name, signature of sampler, sampling station, sample number, date and time of sample collection, grab or composite designation, analytical test method, matrix, preservatives, and signatures of individuals involved in sample transfer. Each custody transfer was documented by signature of the relinquishing and receiving individuals and the date and time of transfer.

2.5.4 Decontamination of Field Equipment

Field equipment used for collection of samples such as bailers, split-spoons, or spatulas was decontaminated between samples in accordance with PEER SOP Q-3, "Decontamination - Field Equipment," which involves the following procedure:

- scrub with laboratory grade detergent such as Liquinox® or Alconox®,
- rinse with tap water,
- rinse with ASTM Type II water,
- rinse with methanol, and
- air dry.

Once air dried, the sampling equipment was wrapped in plastic or aluminum foil, unless placed in immediate use.

All other downhole equipment was decontaminated by steam cleaning between borings. A temporary decontamination pad was constructed on the asphalt parking area designated by the PAANG. Used decontamination fluids were contained in DOT specification steel drums pending disposal by ANG.

2.5.5 Prevention of Cross-Contamination

To prevent cross-contamination, the individuals performing the sampling tasks donned a fresh pair of latex gloves prior to collection of each sample. Sampling equipment such as split spoons and bailers was decontaminated prior to collection of each sample.

Sample containers and sampling equipment were not allowed to come in direct contact with the ground surface or with excavated soils or water. All sample containers and sampling equipment were protected by and placed on plastic sheeting as needed. Plastic ground covers were used as needed.

2.5.6 Field Quality Control Samples

To ensure the reliability of field sampling procedures, field QC samples were collected or prepared for each medium sampled, sample shipment, and sampling event, as described in the following sections.

Duplicates

Six duplicate soil samples were collected. The soil sample for each duplicate was analyzed for either BTEX or TPH by EPA Methods 8020 and 418.1, respectively. One duplicate water sample was collected. The groundwater sample was analyzed for BTEX and TPH by EPA Methods 602 and 418.1, respectively (Table 2.1).

Equipment Rinsate Blank

Nine equipment rinsate blanks were collected to evaluate the effectiveness of the equipment decontamination procedure. The samples were analyzed for BTEX and/or TPH by EPA Methods 602 and 418.1, respectively (Table 2.1).

Trip Blank

Nine trip blanks were analyzed for BTEX by EPA Method 602 (Table 2.1) to evaluate the potential for sample cross-contamination during shipment.

2.6 ADDITIONAL REQUIREMENTS

2.6.1 Waste Management

Waste management activities were conducted in accordance with PEER SOP F-4, "Waste Minimization/Waste Disposal." Investigation-derived wastes such as soil cuttings and decontamination and purge water were collected by the drilling subcontractor and segregated by soil boring into 55-gal open-top drums. The drums were properly identified, and left on-site in a designated area for disposal by WGARS personnel.

A total of 17 drums of soil cuttings, 4 drums of rock cuttings, 4 drums of decontamination water and 3 drums of well development/purge water were generated during the two investigative phases. All of the drums were stored in the MPA area as directed by WGARS personnel. The analytical results for the soil borings were used to develop recommendations for disposal of the investigation-derived wastes, which are provided in Appendix I.

2.6.2 Boring Abandonment

Soil borings were abandoned by filling each borehole with cement/bentonite grout. Surface patches consisted of cold set asphalt patch to match existing materials.

2.6.3 Health and Safety

All SA field activities were conducted in conformance with a site-specific Health and Safety Plan.

3.0 MPA SITE ASSESSMENT FINDINGS

3.1 SITE GEOLOGY

Geologic cross-sections A-A', B-B', and C-C' were constructed from north to south, west to east, and southwest to northeast (Figure 3.1) and are depicted in Figures 3.2, 3.3, and 3.4, respectively. Soils encountered during drilling in the vicinity of the MPA consisted of medium to reddish brown silty clay. Lenses of fine-grained silty sand were noted in several split spoon samples obtained from the soil borings. Asphalt paving areas are underlain by approximately 1.5 ft of a gravel backfill material containing variable amounts of silt, sand, and clay. A weathered, partially indurated siltstone with an approximate thickness of 2.5 ft exists immediately overlying bedrock. Bedrock was encountered at variable depths during drilling activities, ranging from more than 5 ft BGS in SB-14 to more than 18 ft BGS in SB-28. Four soil borings (SB-05, SB-07, SB-10, and SB-19) were drilled into bedrock to obtain information on groundwater beneath the MPA since groundwater was generally not encountered in the soil overburden. Bedrock consisted of a medium to dark reddish-brown sandy siltstone which was interpreted to be the Stockton Formation. Detailed soil descriptions are presented on the soil boring logs (Appendix J). Figure 3.5 presents a contour map of the top of bedrock surface for the MPA vicinity. These data are based on auger refusal depths and indicate a general bedrock slope toward the northwest. Furthermore, they indicate the presence of a depression beneath the MPA which may be influencing movement of TPH constituents.

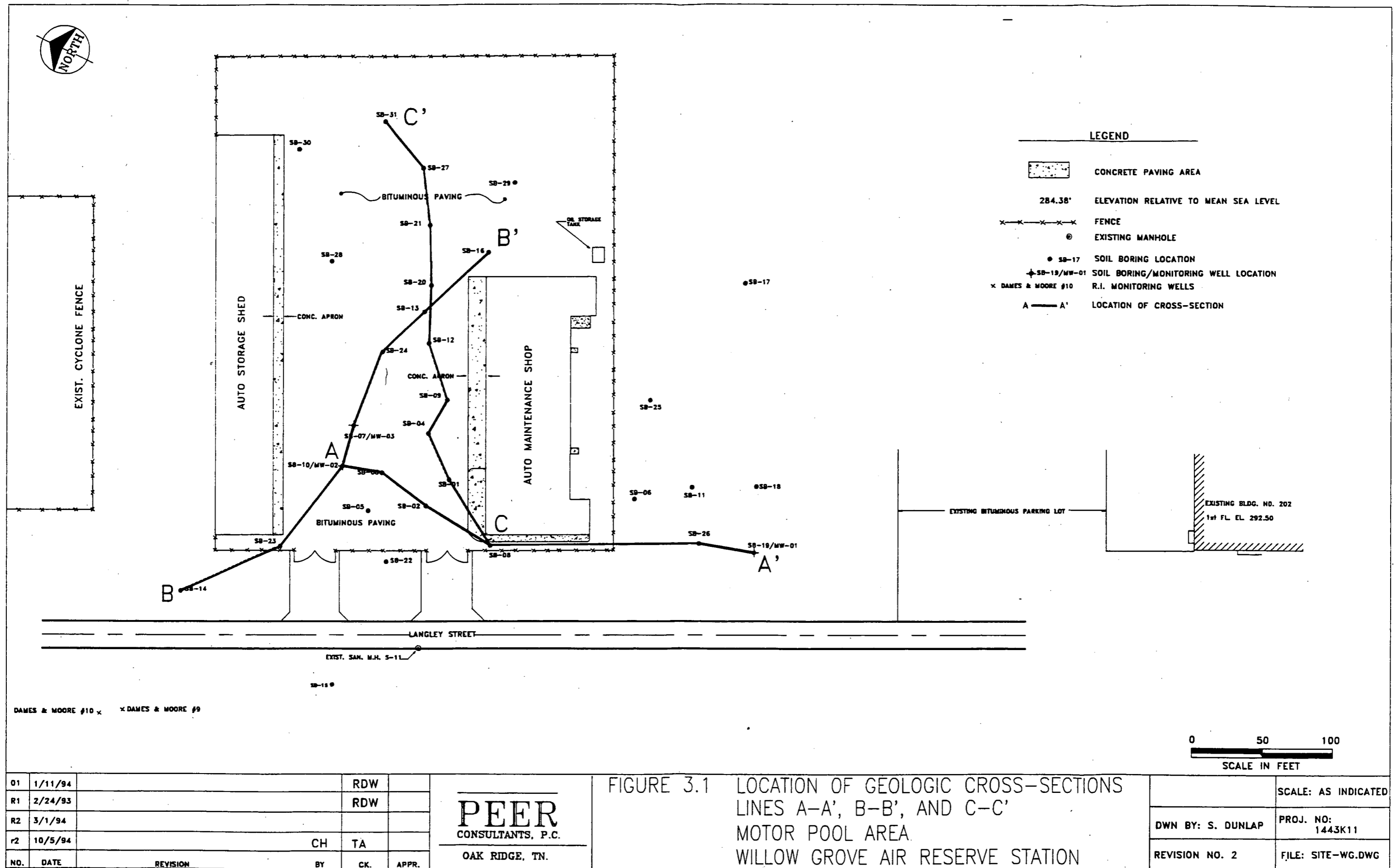
3.2 PERMEABILITY ANALYSIS - MPA SOILS AND BEDROCK

Shelby tube samples (SB-13-08 and SB-14-06) were submitted to a geotechnical laboratory for determination of coefficient of permeability of site soils. The coefficient of permeability was determined to be 1.9×10^{-7} cm/sec for both soil samples. Geotechnical analytical results are summarized in Table 3.1 and a copy of the laboratory report is contained in Appendix K.

Each monitoring well (three total) was slug tested as described in Section 2.4.15. Water levels recovered extremely quickly and the test data proved insufficient to determine hydraulic conductivity of the bedrock aquifer at the new monitoring wells. However, the rapid rate of water level recovery indicates that the aquifer has good hydraulic conductivity. Slug testing completed during the RI indicated a hydraulic conductivity of 2.12×10^{-4} cm/sec in the fractured siltstone tested at RI well DM-10. This monitoring well is located approximately 130 ft west of the MPA.

The difference between the laboratory determination of hydraulic conductivity and the field determination is a result of different units being tested. The laboratory samples were obtained from the unconsolidated (clay) sediments, while the slug testing was completed for the bedrock.

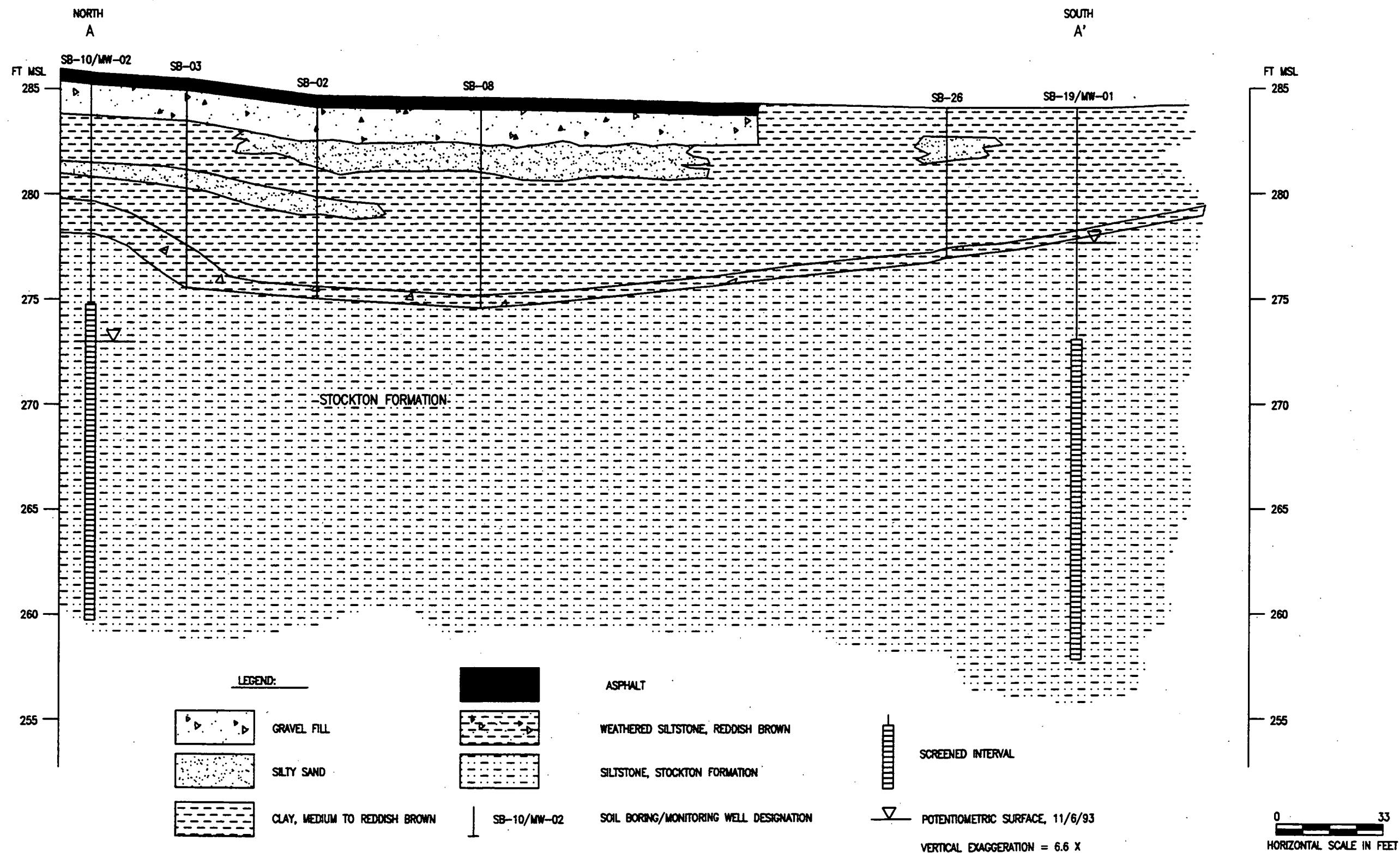
— Good



01	1/11/94		RDW	
R1	2/24/93		RDW	
R2	3/1/94			
r2	10/5/94	CH	TA	
NO.	DATE	REVISION	BY	CK. APPR.

PEER
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OAK RIDGE, TN.

	SCALE: AS INDICATED
DWN BY: S. DUNLAP	PROJ. NO: 1443K11
REVISION NO. 2	FILE: SITE-WG.DWG



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FIGURE 3.2 GEOLOGIC CROSS-SECTION A-A'
MOTOR POOL AREA
WILLOW GROVE AIR RESERVE STATION

DSGN BY: RDW	SCALE: AS INDICATED
DWN BY: C. HALL	PROJ./DISK: 1443K11
REVISION NO. 0	FILE: WG-XSECA.DWG

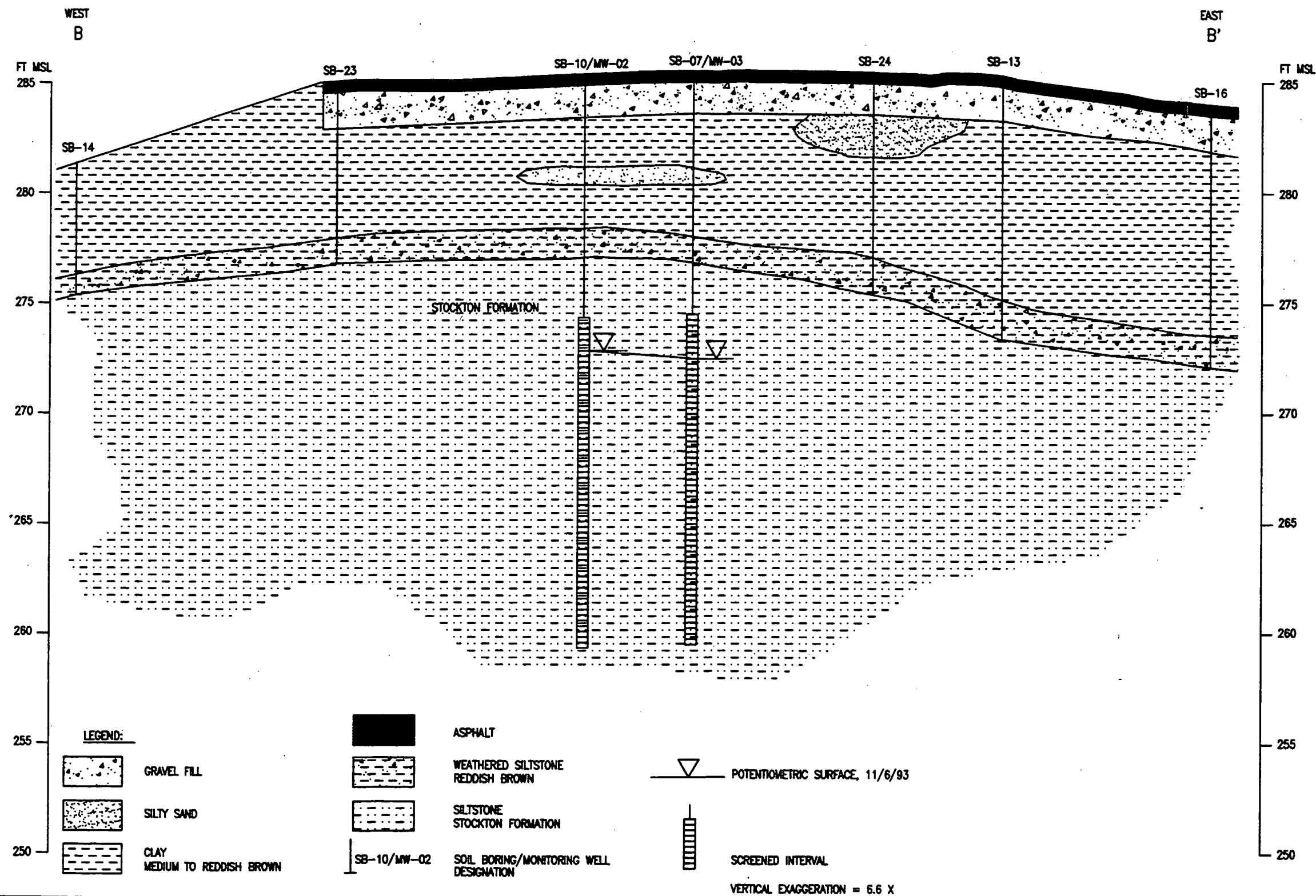
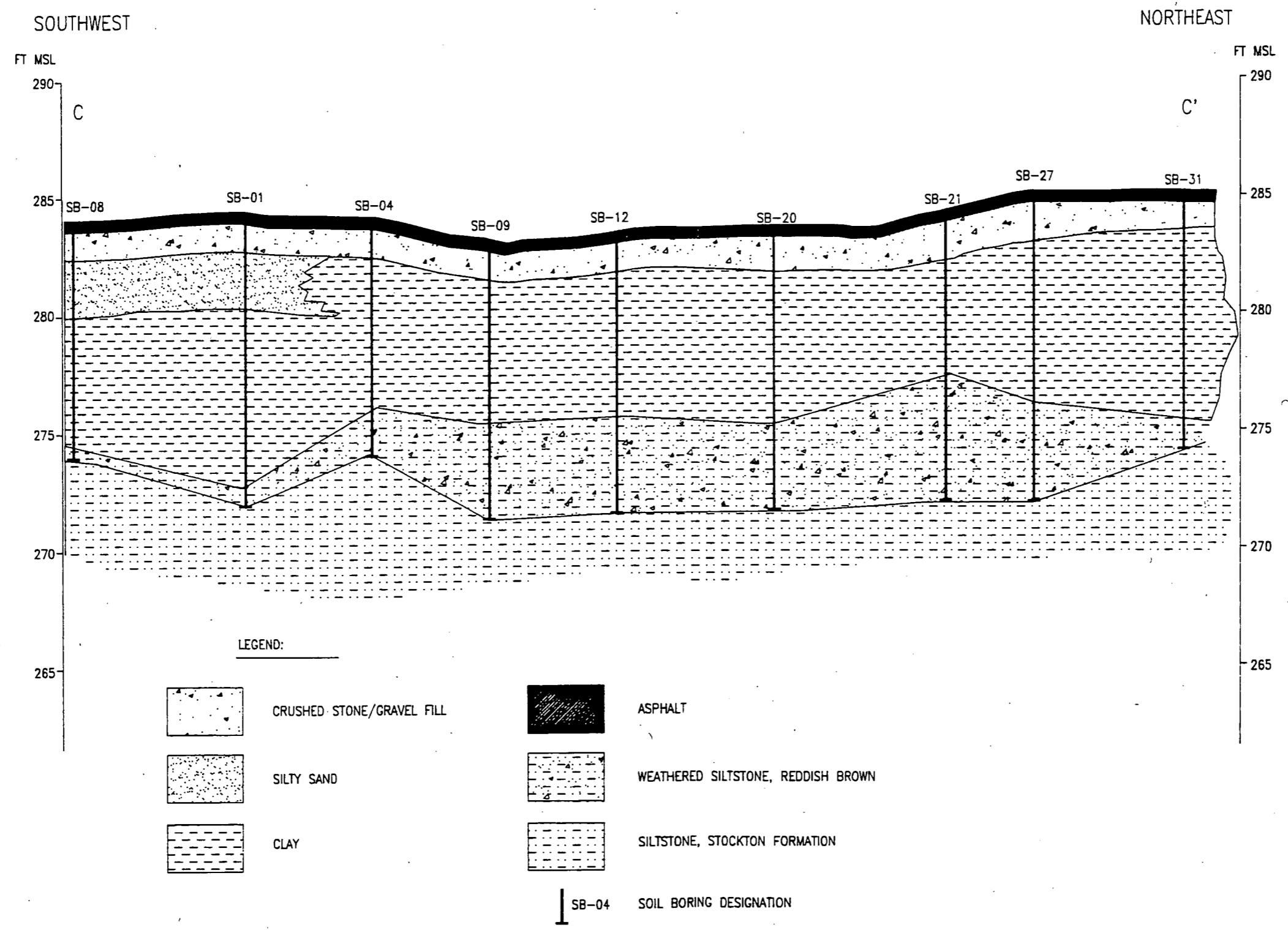


FIGURE 3.3 GEOLOGIC CROSS-SECTION B-B'
MOTOR POOL AREA
WILLOW GROVE AIR RESERVE STATION

DSGN BY: RDW	SCALE: AS INDICATED
DWN BY: C. HALL	PROJ./DISK: 1443K11
REVISION NO. 0	FILE: WG-XSECB.DWG

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CH



						<div>PEER</div> <div>CONSULTANTS, P.C.</div> <div>OAK RIDGE, TN.</div>	FIGURE 3.4	GEOLOGIC CROSS-SECTION C-C'	MOTOR POOL AREA	WILLOW GROVE AIR RESERVE STATION	DSGN BY: T. ASHWORTH	SCALE: AS INDICATED
											DWN BY: C. HALL	PROJ./DISK: 1443K11
			CH								REVISION NO. 0	FILE: WG-XSECC.DWG
NO.	DATE	REVISION	BY	CK.	APPR.							

<p>TABLE 3.1</p> <p>SOIL PERMEABILITY ANALYSIS</p> <p>WILLOW GROVE AIR RESERVE STATION</p>		
Soil Boring Sample No.	Depth (ft) BGS	Coefficient of Permeability (cm/sec)
SB-13-08	6-8	1.9×10^{-7}
SB-14-06	4-6	1.9×10^{-7}

Testing Method - ASTM Method D2434

3.3 SITE HYDROGEOLOGY

Before work commenced on site, it was assumed that the shallow groundwater table would initially be encountered under unconfined conditions within the unconsolidated sediments overlying the bedrock. The reasons for this assumption included:

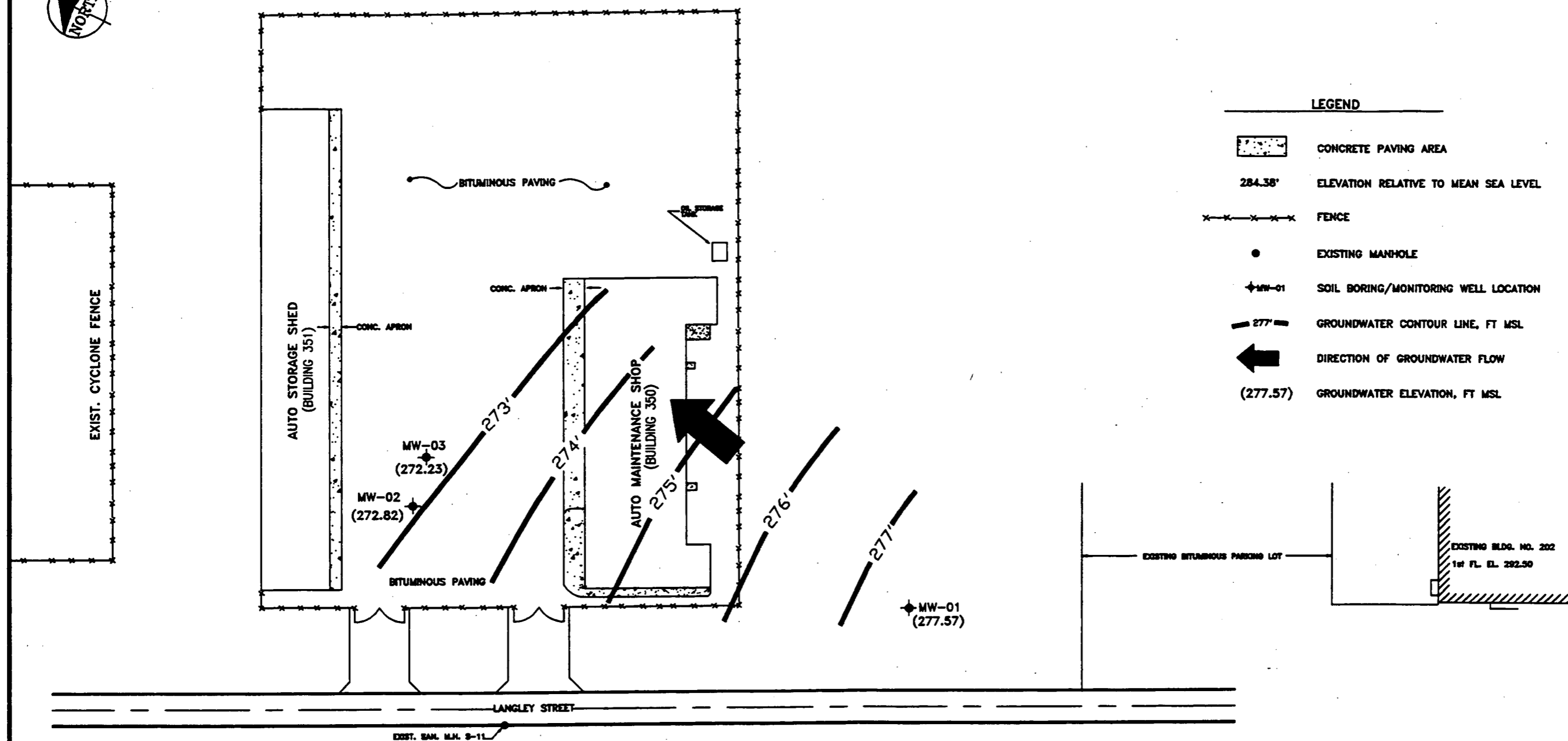
- data from the soil survey⁵ indicating a seasonal high water table of 3 to 5 ft BGS⁶; and
- data from the RI¹ indicating groundwater at the WGARS occurring within the unconsolidated sediments at 10 to 13 ft BGS.

During the SA, it became apparent that bedrock beneath the MPA occurred at a somewhat shallower depth than in areas where the RI was conducted, and as a result, the shallow groundwater table occurred under confined conditions within the bedrock (Stockton Formation) beneath the MPA.

Borings installed to refusal (about 5 ft to about 18 ft BGS) during the initial SA did not encounter saturated conditions. As a result, air rotary drilling was used to advance four borings into the bedrock where water was encountered at approximately 21 ft BGS. Water levels obtained from monitoring wells installed in three of these boreholes (MW-01 through MW-03) on November 6, 1993, are presented in Table 2.2. A potentiometric surface map (Figure 3.6) was constructed using this information, and indicates groundwater flow in the Stockton Formation beneath the MPA is toward the north, from MW-01 toward MW-02 and MW-03. The hydraulic gradient between monitoring wells MW-01 and MW-03 was 0.017 ft/ft on November 6, 1993. During the SA in September 1994, groundwater was encountered in the unconsolidated deposits in one borehole (SB-28) at a depth of 17 ft BGS. Because groundwater elevations observed in MW-01 through MW-03 were generally consistent with data obtained in 1993, a separate potentiometric surface map was not prepared. Based on the measured groundwater elevations, a gradient of 0.017 ft/ft, an assumed effective porosity of 10%, and a hydraulic conductivity of 2.12×10^{-4} cm/sec (D&M RI), a calculation of groundwater velocity in the bedrock can be made using a modified form of Darcy's equation:

$$V = \frac{K i}{n}$$

where K = hydraulic conductivity
 i = groundwater gradient
 n = effective porosity



DAMES & MOORE #10 x DAMES & MOORE #9

0 50 100
SCALE IN FEET

01	1/11/94			RDW	
R1	2/24/93			RDW	
R2	3/1/94				
r2	10/5/94		CH	TA	
NO.	DATE	REVISION	BY	CK.	APPR.

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FIGURE 3.6 POTENTIOMETRIC SURFACE MAP 11/6/93
MOTOR POOL AREA
WILLOW GROVE AIR RESERVE STATION

	SCALE: AS INDICATED
DWN BY: S. DUNLAP	PROJ. NO: 1443K11
REVISION NO. 2	FILE: WG-FIG36.DWG

It is important to note that this calculation is inherently designed for granular media and may not provide a good estimate of flow velocities through fractured rock.

$$v = \frac{0.601 \times 0.017}{0.10}$$

$$= 0.10 \text{ ft/day}$$

good!
but is this relevant?

from RI $K = 2.12 \times 10^{-4} \text{ cm/sec}$
 $= 0.601 \text{ ft/day}$
 $i = 0.017 \text{ ft/ft (Sep. 1994 data)}$
 $n = 10\% (0.10)$

This (SA) computation is based on a K value calculated from a single D&M slug test performed in monitoring well DM-10. It is likely an underestimate because it does not account for fracture flow in the bedrock. The K estimated for monitoring well DM-10 was selected because the well is screened in the bedrock and because of its close proximity to the MPA.

3.4 ANALYTICAL RESULTS - MPA SOILS

A total of 63 soil samples were submitted for TPH analysis by EPA Method 418.1. A total of 10 soil samples were submitted for BTEX analysis by EPA Method 8020 and 73 soil samples for field GC screening for BTEX. Laboratory analytical results are summarized in Table 3.2 and are presented in Appendix F. BTEX field GC screening results are presented in Table E.2 in Appendix E. Two analytical laboratories were utilized during this project: Buck Environmental Laboratory (BUCK) and RECRA Environmental Laboratory (RECRA). Both sets of data reports are included in Appendix F. The data obtained by BUCK were generally more conservative (showed higher concentrations) and it is these data that are presented in the data tables.

*well 2
Labs doing
same samples*

During implementation of the WPA, RECRA was unable to meet the low detection limits obtained by BUCK during the WP implementation. Therefore, the WPA samples were reanalyzed by BUCK to ensure consistency with the first phase of work.

Laboratory analytical results for the soil samples obtained from the MPA indicate that TPH concentrations range from nondetect to 77 $\mu\text{g/g}$. The BTEX field GC screening results for the soil samples were generally non-detect to less than 20 $\mu\text{g/kg}$ total BTEX. Results from two samples (SB-09 and SB-13) were at levels of 1200 $\mu\text{g/kg}$ and 560 $\mu\text{g/kg}$ total BTEX, respectively. Laboratory analytical results for total BTEX indicated concentrations from nondetect to 78.2 $\mu\text{g/kg}$. Based upon the limited detection of BTEX compounds in both the field GC and analytical results, BTEX analyses were discontinued with HAZWRAP, ANGRC approval (documented on Field Change No. 4, Appendix B).

TABLE 3.2

**SUMMARY OF LABORATORY ANALYSES OF PETROLEUM CONSTITUENTS
IN SITE SOILS, WILLOW GROVE AIR RESERVE STATION**

Soil Boring- Sample No.	Depth (ft) BGS	Parameters					
		Benzene ($\mu\text{g/kg}$)	Toluene ($\mu\text{g/kg}$)	Ethylbenzene ($\mu\text{g/kg}$)	Xylenes ($\mu\text{g/kg}$)	BTEX ($\mu\text{g/kg}$)	TPH ($\mu\text{g/g}$)
PADER Guidance Protection Levels	--	10	20	20	70	None	10
SB-01-08	6-8'	ND	ND	ND	1.6	1.6	28.0
SB-01-12	10-12'	ND	2.9	8.9	9.4	21.2	35.0
SB-02-06	4-6'	ND	ND	ND	ND	ND	ND
SB-02-10	8-10'	ND	ND	ND	13.4	13.4	56.0
SB-03-06	4-6'	ND	ND	ND	ND	ND	ND
SB-03-10	8-10'	ND	ND	ND	ND	ND	17.0
SB-04-08	6-8'	ND	ND	ND	ND	ND	ND
SB-04-10	8-10'	5.7	21.5	25.3	25.7	78.2	77.0
SB-05-04	2-4'	NA	NA	NA	NA	NA	ND
SB-05-10	8-10'	NA	NA	NA	NA	NA	29.0
SB-06-04	2-4'	NA	NA	NA	NA	NA	7.0
SB-06-06	4-6'	NA	NA	NA	NA	NA	ND
SB-07-08	6-8'	NA	NA	NA	NA	NA	ND
SB-07-10	8-10'	NA	NA	NA	NA	NA	ND
SB-08-06	4-6'	NA	NA	NA	NA	NA	21.0
SB-08-10	8-10'	NA	NA	NA	NA	NA	ND
SB-09-04	2-4'	NA	NA	NA	NA	NA	ND
SB-09-12	10-12'	ND	13.3	ND	46.2	59.5	61.0
SB-10-04	2-4'	NA	NA	NA	NA	NA	ND
SB-10-08	6-8'	NA	NA	NA	NA	NA	ND
SB-11-06	4-6'	NA	NA	NA	NA	NA	ND
SB-11-08	6-8'	NA	NA	NA	NA	NA	14.0
SB-12-06	4-6'	NA	NA	NA	NA	NA	13.0
SB-12-12	10-12'	NA	NA	NA	NA	NA	48.0
SB-13-06	4-6'	NA	NA	NA	NA	NA	5.0
SB-13-12	10-12'	NA	NA	NA	NA	NA	40.0
SB-14-02	0-2'	NA	NA	NA	NA	NA	9.0
SB-14-06	4-6'	NA	NA	NA	NA	NA	ND
SB-15-02	0-2'	NA	NA	NA	NA	NA	7.0
SB-15-08	6-8'	NA	NA	NA	NA	NA	ND
SB-16-04	2-4'	NA	NA	NA	NA	NA	6.0
SB-16-12	10-12'	NA	NA	NA	NA	NA	ND
SB-17-02	0-2'	NA	NA	NA	NA	NA	ND
SB-17-07	5-7'	NA	NA	NA	NA	NA	ND
SB-18-06	4-6'	NA	NA	NA	NA	NA	5.0
SB-18-08	6-8'	NA	NA	NA	NA	NA	ND
SB-19-02	0-2'	NA	NA	NA	NA	NA	16.0
SB-19-06	4-6'	NA	NA	NA	NA	NA	ND
SB-20-10	8-10'	NA	NA	NA	NA	NA	ND
SB-20-12	10-12'	NA	NA	NA	NA	NA	15

TABLE 3.2 (Continued)

SUMMARY OF LABORATORY ANALYSES OF PETROLEUM CONSTITUENTS
IN SITE SOILS, WILLOW GROVE AIR RESERVE STATION

Soil Boring- Sample No.	Depth (ft) BGS	Parameters					
		Benzene ($\mu\text{g/kg}$)	Toluene ($\mu\text{g/kg}$)	Ethylbenzene ($\mu\text{g/kg}$)	Xylenes ($\mu\text{g/kg}$)	BTEX ($\mu\text{g/kg}$)	TPH ($\mu\text{g/g}$)
PADER Guidance Protection Levels	—	10	20	20	70	None	10
SB-21-10	8-10'	NA	NA	NA	NA	NA	42.0
SB-21-12	10-12'	NA	NA	NA	NA	NA	7.0
SB-22-04	2-4'	NA	NA	NA	NA	NA	ND
SB-22-08	6-8'	NA	NA	NA	NA	NA	66
SB-23-04	2-4'	NA	NA	NA	NA	NA	ND
SB-23-08	6-8'	NA	NA	NA	NA	NA	ND
SB-24-04	2-4'	NA	NA	NA	NA	NA	ND
SB-24-10	8-10'	NA	NA	NA	NA	NA	ND
SB-25-04	2-4'	NA	NA	NA	NA	NA	ND
SB-25-06	4-6'	NA	NA	NA	NA	NA	ND
SB-26-06	4-6'	NA	NA	NA	NA	NA	6.0
SB-26-08	6-8'	NA	NA	NA	NA	NA	12
SB-27-05	3-5'	NA	NA	NA	NA	NA	51.1
SB-27-11	9-11'	NA	NA	NA	NA	NA	45.2
SB-27-13	11-13'	NA	NA	NA	NA	NA	56.8
SB-28-04	2-4'	NA	NA	NA	NA	NA	62.6
SB-28-10	8-10'	NA	NA	NA	NA	NA	38.3
SB-29-06	4-6'	NA	NA	NA	NA	NA	23.2
SB-29-08	6-8'	NA	NA	NA	NA	NA	55.7
SB-30-04	2-4'	NA	NA	NA	NA	NA	ND (20)
SB-30-12	10-12'	NA	NA	NA	NA	NA	61.5
SB-31-04	2-4'	NA	NA	NA	NA	NA	58.0
SB-31-08	6-8'	NA	NA	NA	NA	NA	ND (20)

- NA - Not analyzed.
 ND - Not detected: Detection limit is 1.0 $\mu\text{g/kg}$ for BTEX Compounds. Detection limit is 5 $\mu\text{g/g}$ for TPH
 BTEX - Compounds; Analyzed by EPA Method 5030/8020
 TPH - Analyzed by EPA Method 418.1

Shaded concentrations exceed PADER Protection Levels.

PADER Protection Levels were converted to $\mu\text{g/kg}$ and $\mu\text{g/g}$ concentrations in order to facilitate comparison with the site data.

No they don't

Figure 3.7 presents a summary of TPH distribution in MPA soils. It is believed that the TPH exceedances at borings SB-26 and SB-14 are anomalous and may be a result of near-surface contamination by upgradient sources. As they lie upgradient with respect to groundwater flow and topographically upslope from the former USTs at the MPA, it is unlikely that they represent contamination from the reported release. Because only one soil sample obtained from soil boring SB-04 exceeded the PADER guidance levels for BTEX, specifically for ethylbenzene and toluene, these data are not presented on a figure. The proximity of this boring to the tank excavation means that this result is not surprising. None of the other BTEX constituents exceeded their respective protection levels in this or in other borings.

3.5 ANALYTICAL RESULTS - MPA GROUNDWATER

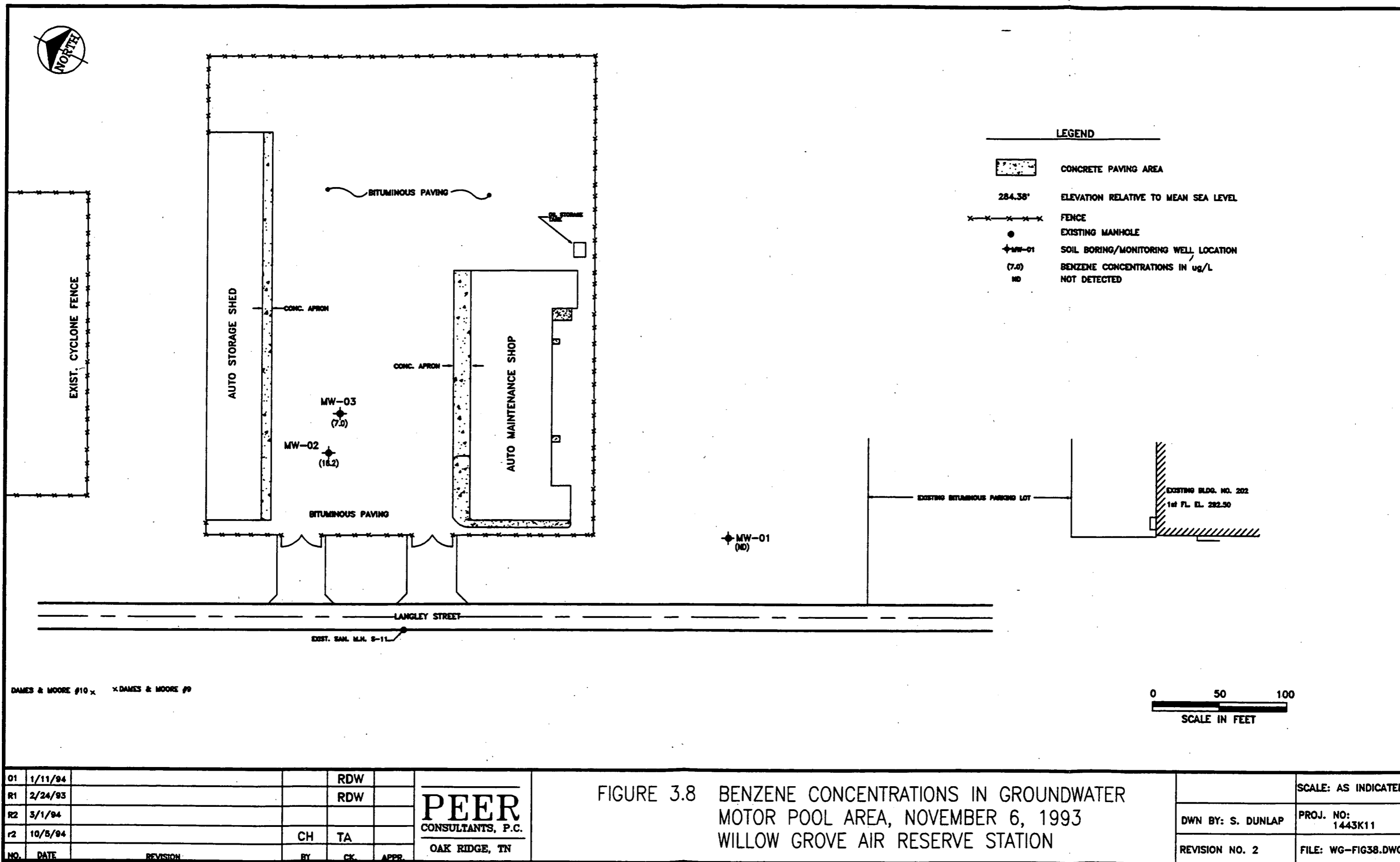
Groundwater samples obtained from the monitoring wells installed during the SA were analyzed for BTEX using EPA Method 602 and for TPH using EPA Method 418.1. Groundwater sample MW-01-01 obtained from upgradient monitoring well MW-01 did not contain detectable concentrations of BTEX or TPH constituents. Groundwater sample MW-02-01 obtained from downgradient monitoring well MW-02 and groundwater sample MW-03-01 obtained from downgradient monitoring well MW-03 contained 16.2 $\mu\text{g/L}$ and 7.0 $\mu\text{g/L}$ of benzene, respectively. These benzene concentrations exceed the PADER MCL of 5 $\mu\text{g/L}$ for benzene. Groundwater analytical results are summarized in Figure 3.8 and Table 3.3. A copy of the laboratory report is contained in Appendix F.

Both groundwater samples which exceed the PADER MCLs were collected from monitoring wells located downgradient of the former tank system. Monitoring well MW-03 is located slightly down and sidegradient from the former tank system location. Monitoring well MW-02 is located directly downgradient of the former tank system. This location difference is the probable cause of the different benzene concentrations in the groundwater. The upgradient monitoring well did not contain detectable concentrations of BTEX or TPH constituents.

3.6 ANALYTICAL RESULTS - QUALITY CONTROL SAMPLES

Trip blanks were submitted to the laboratory in conjunction with soil samples collected during the SA to assess possible contamination of the sample vials during transport. The trip blanks were analyzed for BTEX constituents using EPA Method 602. Analytical results are summarized in Table 3.4 and a copy of the analytical report is contained in Appendix F.

Equipment rinsate samples were submitted to the laboratory for analysis as a measure of the effectiveness of the decontamination procedure. The rinsate samples were collected from a sampling spatula and analyzed for BTEX constituents by EPA Method 602. Analytical results are summarized in Table 3.4 and a copy of the analytical report



<p align="center">TABLE 3.3</p> <p align="center">SUMMARY OF LABORATORY ANALYSES OF PETROLEUM</p> <p align="center">CONSTITUENTS IN GROUNDWATER</p> <p align="center">NOVEMBER 6, 1993</p> <p align="center">WILLOW GROVE AIR RESERVE STATION</p>						
Sample ID	Benzene ($\mu\text{g/L}$)	Toluene ($\mu\text{g/L}$)	Ethylbenzene ($\mu\text{g/L}$)	Xylenes ($\mu\text{g/L}$)	BTEX ($\mu\text{g/L}$)	TPH (mg/L)
PADER MCLs	5	1000	700	10000	NA	NA
MW-01-01	ND	ND	ND	ND	ND	ND
MW-02-01	16.2	ND	22.6	60.1	98.9	41.0
MW-03-01	7.0	ND	24.4	52.0	83.4	22.0
SB-05-6W	ND	ND	ND	ND	ND	ND

NA = Not applicable. No action level specified.

ND = Not detected greater than the detection limit; detection limit for BTEX compounds is 1.0 $\mu\text{g/L}$; detection limit for TPH is 2.0 mg/L.

BTEX compounds analyzed by EPA Method 602 TPH analyzed by EPA Method 418.1.

TABLE 3.4					
QUALITY CONTROL - ANALYTICAL RESULTS WILLOW GROVE AIR RESERVE STATION					
Sample	Parameters				
	Benzene μg/L	Toluene μg/L	Ethylbenzene μg/L	Xylenes μg/L	TPH mg/L
Trip Blank					
10-19-93	ND	ND	ND	ND	NR
10-21-93	ND	ND	ND	ND	NR
10-25-93	ND	ND	ND	ND	NR
10-28-93	ND	ND	ND	ND	NR
11-01-93	ND	ND	ND	ND	NR
11-03-93	ND	ND	ND	ND	NR
11-04-93	ND	ND	ND	ND	NR
11-06-93	ND	ND	ND	ND	NR
Equipment Blank					
10-19-93	ND	ND	ND	ND	NR
10-21-93	ND	ND	ND	ND	NR
10-25-93	ND	ND	ND	ND	ND
10-28-93	ND	ND	ND	ND	ND
11-01-93	ND	ND	ND	ND	ND
11-03-93	1.7	ND	1.8	3.3	ND
11-04-93	ND	ND	ND	ND	ND
11-06-93	ND	ND	ND	ND	ND
Soil Duplicates					
	μg/kg	μg/kg	μg/kg	μg/kg	μg/g
Duplicates 01 (SB-09-12)	ND	38.9	14.8	62.9	78.0

→ Show original and the duplicate on the same table

TABLE 3.4 (continued)					
QUALITY CONTROL - ANALYTICAL RESULTS WILLOW GROVE AIR RESERVE STATION					
Duplicates 02 (SB-12-12)	NR	NR	NR	NR	21.0
Duplicates 03 (SB-20-10)	NR	NR	NR	NR	ND
Duplicates 04 (SB-21-10)	NR	NR	NR	NR	29.0
Duplicates 05 (SB-25-06)	NR	NR	NR	NR	ND
Duplicate 00 (SB-29-08)	NR	NR	NR	NR	34.3
Duplicate 06 (MW-03-01)	Groundwater Duplicate				
	8.6 µg/L	ND µg/L	32.4 µg/L	73.1 µg/L	26.0 µg/L

NR = Not Requested to be analyzed

ND = Not Detected; Detection limit for BTEX in soils is 5.0 µg/kg;
Detection limit for TPH in soils is 5.0 µg/g; Detection limit for BTEX in water is 1.0 µg/L; Detection limit for TPH in water is 2.0 mg/L

BTEX compounds in water analyzed by EPA Method 602

TPH in water analyzed by EPA Method 418.1

BTEX compounds in soil analyzed by EPA Method 5030/8020

TPH in soil analyzed by Method 418.1

is contained in Appendix F. Seven duplicate soil samples were submitted to the laboratory as a check of the reproducibility of the laboratory analytical procedures. The duplicate soil samples were analyzed for TPH using EPA Method 418.1. Two of the duplicate soil samples were analyzed for BTEX constituents using EPA Method 8020. Analytical results are summarized in Table 3.4 and presented in Appendix F.

Analytical results of duplicate soil samples were consistent with analytical results of soil samples, given the difficulty of obtaining truly representative soil matrix duplicates. o/c

A duplicate groundwater sample from MW-03 was submitted for BTEX constituents by EPA Method 602 and TPH constituents by EPA Method 418.1. Analytical results are consistent with analytical results of the groundwater sample.

→ ~~This st~~ ~~Discuss results~~ here

4.0 CONCLUSIONS AND RECOMMENDATIONS

The SA work was completed at the MPA in accordance with the approved WP and its amendments. Work was completed in two phases implemented in October/November 1993 and during September 1994. All work was conducted with the approval of the HAZWRAP and ANG Program Managers.

The SA was conducted to establish areal extent of soil and groundwater impacts caused by a release from a former UST located within the MPA. A total of 63 soil samples and 3 groundwater samples were analyzed for BTEX and/or TPH content. These sample totals do not include QA/QC samples. Soil data were also obtained so that descriptions of the site soil profile could be made. Two soil samples were submitted for laboratory determination of hydraulic conductivity. Therefore, the soil investigation program included both chemical and geotechnical characterization.

The MPA surficial cover consists of an asphalt parking lot underlain by approximately 1.5 ft of crushed stone backfill. The soils beneath the backfill have been reworked and consist of a silty clay. Laboratory permeability testing of two samples of this silty clay indicate a vertical permeability of approximately 1.9×10^{-7} cm/sec. This indicates that the soils constitute a good barrier to the downward percolation of liquid. Therefore, recharge to the bedrock aquifer is likely to be low in the vicinity of the MPA. The asphalt parking lot will also provide an additional barrier to the downward percolation of rainfall and any surficial releases of liquids.

The bedrock surface is irregular beneath the MPA and occurs at shallow depths ranging from about 6 ft to 18 ft BGS. Geological cross-sections indicate a depression in the bedrock surface in the vicinity of the former tank locations. This may indicate that the tanks were partially set in the rock. However, no data are available to indicate the depths at which the former USTs were located. Bedrock generally is dipping toward the northwest beneath the MPA.

Groundwater flow direction in bedrock (under confined conditions) was toward the north and northwest during both SA phases conducted in 1993 and 1994. These SA data also proved consistent with the earlier 1988 RI data. Depth to groundwater in site wells which penetrate bedrock ranged between (approximately) 6.5 ft BGS to 13.1 ft BGS during both phases of the SA. Depth to groundwater in soil boring SB-28 was also consistent with the monitoring well measurements noted above.

The interpreted groundwater flow direction places the MPA in a downgradient position relative to the WGARS flight line, aircraft maintenance hanger, and fuel cell maintenance dock. The MPA is also located upgradient of the areas investigated during the Dames & Moore 1988 RI. Based on the RI data, the MPA may be located within the area influenced by recharge to groundwater from the ponding basin located west of the MPA. The RI data indicate that this pond acts as a source of recharge to groundwater during periods of high water levels in the pond.

Chemical analysis of the SA media samples indicated the following:

- impacts to the unconsolidated soils by TPH exist both within the MPA and in areas outside the MPA,
- concentrations of TPH in the soil ranged from non detect (less than 5 $\mu\text{g/g}$) to 79 $\mu\text{g/g}$,
- soil samples from four of the five borings submitted for laboratory BTEX analyses contained BTEX constituents (one sample exceeded the PADER Protection Levels), and

groundwater is impacted by BTEX and TPH constituents at locations immediately downgradient of the former tank excavation.

The area of soil impacted by TPH has been defined to the northwest, west, southwest, and east of the former UST. However, the boundary of TPH impacted soil toward the northeast has not been defined. The TPH impacted soils associated with the former USTs occur within the unconsolidated deposits. Generally the depth of impacted soils is 8 to 12 ft BGS in the vicinity of the former UST locations. This is consistent with a subsurface release mechanism, i.e., a leaking UST. As soil sampling proceeds toward the northeast, the depth to impacted soils decreases. Figure 4.1 presents a soil sampling profile along geologic cross-section line C-C' and Figure 4.2 shows a map of the soils which exceed the 10 $\mu\text{g/g}$ TPH protection level; i.e., soils which lie within this isocontour for the MPA. Figure 4.1 clearly illustrates the changing depth of maximum TPH impacts towards the northeast. These data tend to indicate that the shallow TPH impacts in the north eastern area of the MPA may result from surface releases and may not be a result of subsurface releases from the former USTs. The direction of groundwater flow toward the north and northwest further supports this hypothesis. Another possible soil impacting mechanism would be residual contamination left in the soil by seasonal variations in the water table. Greater concentration of TPH would be expected closer to the water table (i.e., at greater depth in the soil column) if this were true. Clearly in the northeastern area of the MPA, this is not the case.

Groundwater samples obtained from the vicinity of the former UST location in 1993 contained concentrations of benzene in excess of 0.005 mg/L. Headspace screening was conducted in the monitoring wells using a PID during September 1994 in accordance with PEER's Health and Safety Plan, and the results are summarized below:

MW-1	4 ppmv
MW-2	2000 ppmv
MW-3	1100 ppmv

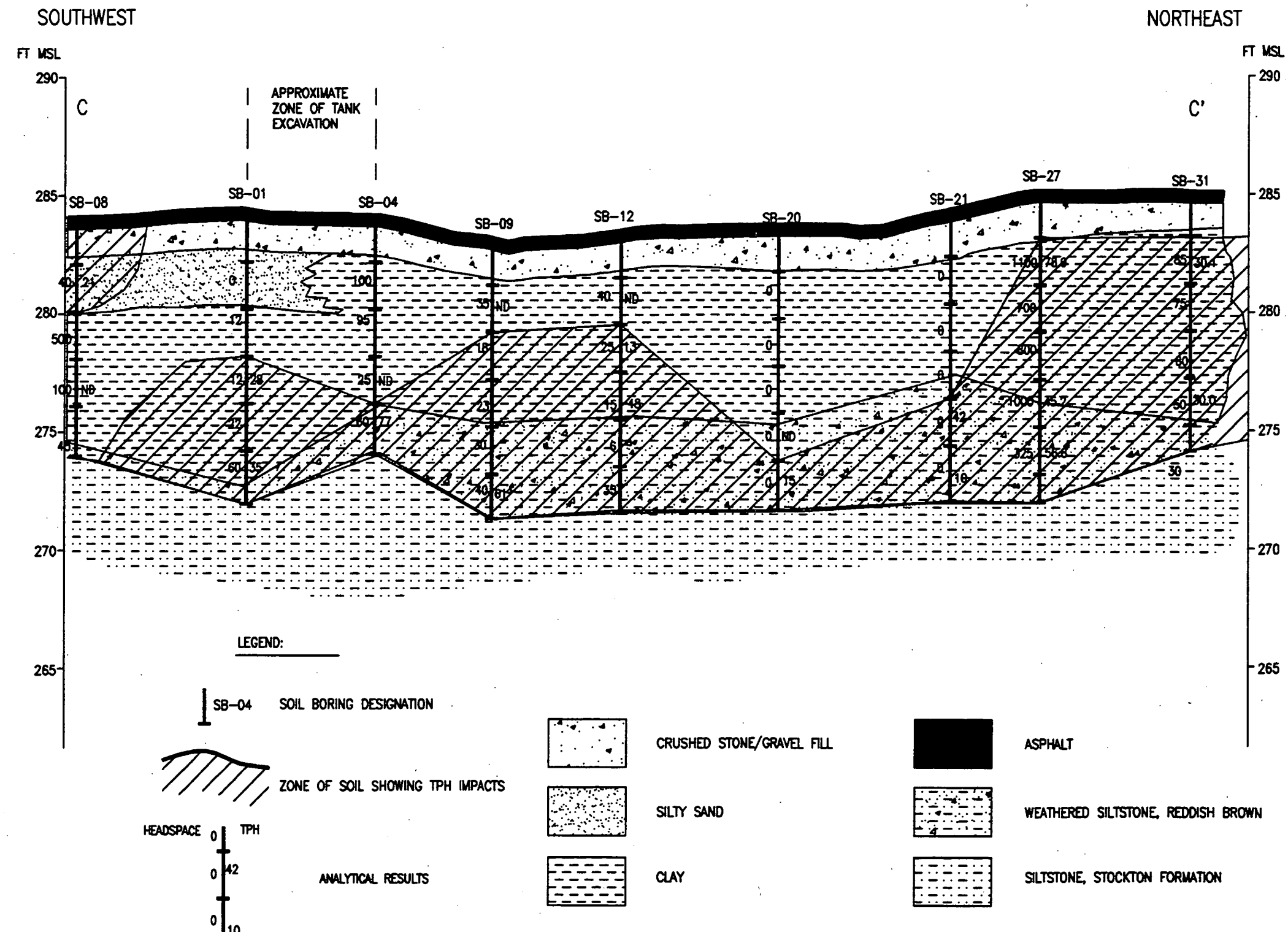
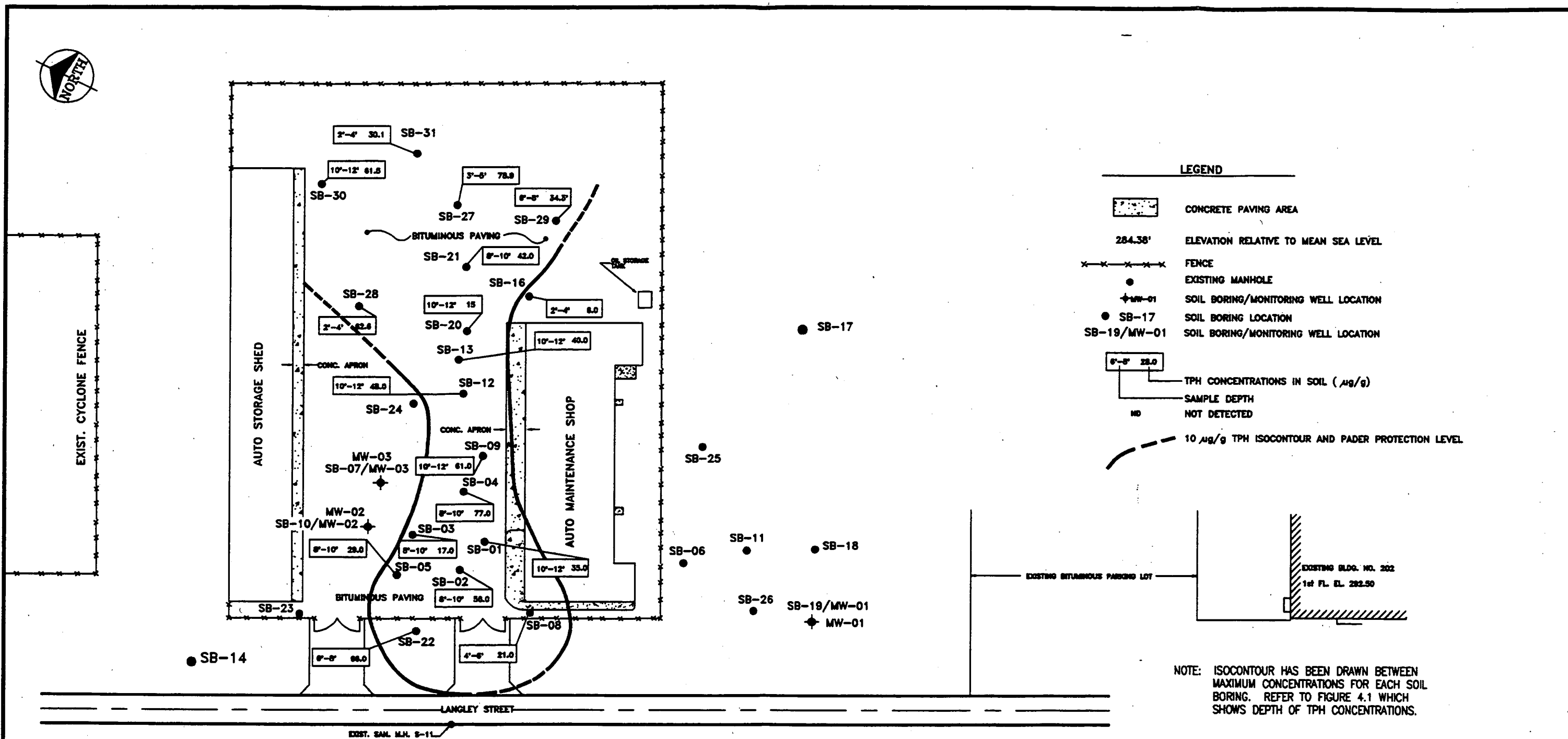


						FIGURE 4.1 SOIL PROFILE OF HEADSPACE AND ANALYTICAL RESULTS, CROSS-SECTION C-C'		DSGN BY: T. ASHWORTH	SCALE: AS INDICATED
						MOTOR POOL AREA		DWN BY: C. HALL	PROJ./DISK: 1443K11
						WILLOW GROVE AIR RESERVE STATION		REVISION NO. 0	FILE: WG-FIG41.DWG

PEER
CONSULTANTS, P.C.
OAK RIDGE, TN



DAMES & MOORE #10 x x DAMES & MOORE #9

01	1/11/94			RDW	
R1	2/24/93			RDW	
R2	3/1/94				
r2	10/5/94		CH	TA	
NO.	DATE	REVISION	BY	CK.	APPR.

PEER

CONSULTANTS, P.C.

OAK RIDGE, TN

FIGURE 4.2 10 µg/g TPH ISOCONCENTRATION CONTOUR
MOTOR POOL AREA
WILLOW GROVE AIR RESERVE STATION

	SCALE: AS INDICATED
DWN BY: S. DUNLAP	PROJ. NO: 1443K11
REVISION NO. 2	FILE: WG-FIG42.DWG

Capt
Frattarelli

No groundwater samples were collected in September 1994 so it is not known if the monitoring well headspace results represent accumulations of soil gas or volatilization of constituents from groundwater. However, it should be noted that the headspace data were recorded with a PID (Section 2.4.6), an instrument that is susceptible to fluctuations related to air humidity. No free product was noted while taking the 1994 water level measurements.

Hydrogeological data presented in the RI indicate a groundwater flow rate of 125 to 400 ft per year in the unconsolidated sediments. These estimates were made based on the data obtained for unconsolidated sediments at DM-5 and DM-12. However, the groundwater flow rate in the bedrock may be different from these estimates. Using flow rate data presented in the RI, and a release date of 1990, groundwater impacts caused by the tank release could have moved between 500 to 1600 ft toward the north and northwest. This would place the leading edge of any contamination front originating at the MPA, within the area of impacted groundwater and soils investigated by the RI.

4.1 RECOMMENDATIONS

The following recommendations are made based on the preceding data.

1. Verify the 1993 groundwater data by sampling the three monitoring wells. These data will permit an evaluation of the 1994 monitoring well headspace results and will provide a comparison with the 1993 results. The data will also allow an evaluation of upgradient water quality (MW-1) and will assist in determining the source of the 4 ppm MW-1 headspace reading obtained in September 1994.
2. Analysis of the groundwater samples should include BTEX analysis (U.S. EPA Method 602), ~~Target Compound List (TCL) volatile organic compounds (VOC) and semivolatile organic compound (SVOC) analyses (US EPA Methods 8010, 8020 and 8270 respectively).~~ OK
} NO!
3. Collect four additional soil samples: two from the vicinity of soil boring SB-27 and two from the vicinity of soil boring SB-20. Soil sample depths should be selected so that shallow and deep samples are collected from each boring. Soil samples should be analyzed for TCL-VOC and TCL-SVOC (U.S. EPA Methods 8240 and 8270, respectively). These data would permit a (fingerprint type) comparison of the shallow and deep TPH impacts. This comparison would be useful in assessing potential contamination sources.
4. Petition PADER to permit a risk-based cleanup of the MPA. Factors to consider in petitioning for a risk based cleanup include:

- The MPA is located within a secured area with restricted public access.
- The MPA surface cover is asphalt and is well graded to prevent accumulation of storm waters. These two factors will mitigate the infiltration of precipitation and reduce the downward transport of contaminants.
- The unconsolidated overburden soils have a vertical permeability of the order 1.9×10^{-7} cm/sec and will therefore retard the downward migration of rainfall and contaminants.
- The MPA is surrounded by other potential source areas of TPH and is located downgradient of the flight line and fuel cell maintenance building.
- Upgradient soil impacts in excess of 10 ppm exist in soil borings SB-11, SB-26, and SB-19.
- The RI established a background concentration of TPH in soil to be 50 ppm. This sample was obtained from an off-base area. Most of the MPA soil sample TPH concentrations are less than this.
- The downgradient areas from the MPA are undergoing a remedial investigation/feasibility study process and will be the subject of future remediation. The remedial process will address groundwater impacts including those caused by the one-time tank release from the MPA.

If a risk-based closure is acceptable to PADER, additional sampling may be required to obtain data for the risk assessment.

↳ purpose driven!

5.0 REFERENCES

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